APPLIED MECHANICS Reviews

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APPLIED MECHANICS REVIEWS

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BIOMECHANICS

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MAN performs physical activities in a variety of ways. The manner in which he performs these activities is influenced by his body build, physiological functions, and psychomotor patterns. The problem of human physical activities has received increased attention as the complexity of the tasks man must perform has increased. It has been studied by several scientific disciplines. One of these disciplines is biomechanics.

The intent of this brief paper is to explain the essential nature of biomechanics.

SOME HISTORICAL REMARKS

Biomechanical principles were being applied intuitively in work activities in the Lower Paleolithic Age, when the primitive food collector started to use his first tools and weapons—a piece of stone and a club. For efficient use he had to choose objects which were properly adjusted to his power and his grasp. This primitive method of learning practical biomechanics, by trial and error, continues in the activities of modern every-day life.

A second stage started with the revolution in food production during the Neolithic Age. The increasing division of labor brought a continuous production of new tools and implements which were being steadily improved. Thus in old agricultural nations the size and proportions of the most common agricultural tools and implements were being determined by the size of the operator's body and limbs. In this fashion, many "folk norms" and "rules of thumb" for the proper proportioning of tools were derived.

The first systematic observations on human movements were made by Leonardo da Vinci (1452–1519) and described in his "Notes on the Human Body." During the Renaissance, Galileo and Newton established the experimental and theoretical bases for the analysis of movement. One of Galileo's pupils, Borelli (1608–1679), combined the sciences of mathematics, physics, and anatomy in the first treatise dealing with biomechanics, "DeMotu Animalium," published in 1679–1680 (14).[1] The scientists of the 18th century, Bernoulli, Euler, and especially Coulomb, tried to develop mathematically a rational formula for the determination of the maximum and optimum of human work capacity as a function of force, velocity, and duration of activity (6, 17).

The third stage in development of biomechanics-scientific research started in the second half of the 19th century with investigations of the French School (Marey, Carlet, Demeny, Bull) on human and animal locomotion and bird and insect flights (16, 18, 42, 43). Further improvement in recording motion and reduction methods were made by Fischer. His papers on biomechanics and his books covering the theoretical basis of the mechanics of the living body (30) and on the kinematics of organic linkage (31) are classics. Other good sources for studies on biomechanics during this period are the three volumes by Fick entitled "The Handbook of Anatomy and Mechanics of Joints" (29) and the four volumes of "Textbook of Muscles and Joints Mechanics" by Strasser (61).

Not much attention was paid to the effectiveness of human movements until Taylor in 1881 started his scientific analyses for the improvement of human methods of work. F. Gilbreth and Dr. L. Gilbreth in their book "Applied Motion Study" presented an excellent example of the methods of studying work and improving it (33). The work of the Gilbreths has been continued by Barnes, Holmes, and Porter. A good review of the studies conducted in biomechanics up to the year 1914 is given by Amar in his famous book "The Human Motor" (1).

The Russian contribution to biomechanics was initiated in 1922 under the direction of Bernshtein. By 1950, Bernshtein and his pupils (Popova, Spielberg, Sorokin) had published many papers and books on work and sports motions (7–13, 50). In 1926, Bernshtein published the first part of an exemplary treatise, "General Biomechanics" (8).

Impetus was given to biomechanical research by the two World Wars. During World War I and shortly thereafter, studies on the improvement of prosthetic devices were performed in France by Amar (3) and in Germany by Schlesinger (55). They were the founders of the biomechanics of prosthetic functions. More recently intensive research in walking and in

[1] Numbers in parentheses indicate References at end of paper.

prosthetic needs for amputees has been accomplished. A number of reports and monographs have been published by the Engineering Research Institute of the University of California under the direction of Eberhart and Inman (25), and by the Prosthetic Devices Study at New York University under the direction of Contini and Fishman (51).

DEFINITION

Every human or animal motor performance involves a distribution of forces in time and space. These forces are of two different kinds: internal and external. The internal forces are generated in the muscles and transmitted to tools, controls, wheels, and other objects by elastic transmission systems, the limbs. The external forces are the force of gravity, force of inertia, air resistance, and ground reactions. At rest the internal and external forces are in equilibrium; in movement the resultant of these forces is different from zero.

Since the term biomechanics is frequently misused, it is desirable to define it.

Biomechanics is the science which investigates the effect of internal and external forces on human and animal bodies in movement and rest. It utilizes the fundamental findings of theoretical mechanics, anatomy, and kinesiology, the physiology of the neuromuscular system, psychomotorics, and anthropometry. To these, biomechanics adds a new systematic knowledge which it has itself developed.

PROBLEMS AND METHODS

The problems of biomechanics are multiform. In many cases, a successful solution inevitably requires the close cooperation between biomechanists, anatomists, physiologists, and psychologists. In practice, a distinction must be made between general and applied biomechanics. General biomechanics considers the basic laws and rules of human and animal motion. It is subdivided into biostatics and biodynamics. Biostatics deals essentially with force analysis as well as with the equilibrium of forces acting on organic bodies or segments at rest or moving at a uniform velocity in a straight line.

Biostatic analysis starts with an investigation of posture and its change during performance of an activity, studying the position of the entire body and its parts. When dealing with tools, controls, or wheels, the description of different kinds of grasp used is also important. The next step is the determination of all external forces and their magnitude, direction of action and influence zones on the body. Subsequently follows an analysis of equilibrium with a determination of placement of feet, contact areas with ground or seat, shape and size of support base, vertical loads, fore and after shears and torque. Since during the activity most of the body segments are acting as levers, the class, fulcrum points, and application points of force and load should be noted for the essential levers of activity. Biostatic analysis permits the discovery of errors of posture and equilibrium and the possibilities of improving them.

The biomechanical analysis of forces and movements calls for methods of recording which show sufficient precision, which are not influenced by the mechanism of transmission, which permit quantitative measurement and enable a simple reduction of data. Biomechanics has availed itself of four different methods for objective recording: mechanical, pneumatic, optical, and electrical.

To record changes of the magnitude of forces between the feet and the ground, first, a pneumatic method, introduced by Marey, was used (43). Afterward, mechanical methods developed by Amar (2) and Basler (5) were adopted. Recently these methods were replaced by an electrical method using specially constructed force plates with strain gages. At the present time, for measurement and recording of pressure changes and impact, piezoelectric and condensor devices are also used.

Biodynamic analysis, for convenience, commonly is divided into kinematic and kinetic analysis. Kinematic analysis essentially is concerned only with the time-space relationship. It starts with the study of the time pattern of motion, including a statement of main phases, and its ratios and cadence. Afterward the shape, size, and position of the motion path in plane or space are studied. From the recorded displacement curves the location of singular points can be measured. Curves of displacement vs. time can be plotted, or a system of empirical parametric equations can be computed. The velocities and accelerations are determined by graphical or analytical differentiation.

For the permanent recording or fixation of movement, optical methods have been used. The earliest method of chronophotography was introduced by Marey but has now been replaced by strobography. To study work motions, Gilbreth introduced cyclography and chronocyclography, using small electrical bulbs which were attached to the moving human limbs. The Prosthetic Devices Study at New York University and the Prosthetic Testing and Development Laboratory of the Veterans Administration are now using highly reflective tape (scotchlite) which acts as a brightly illuminated target. The points and lines marked with scotchlite show up on the record as "sticks," indicating their position in space (49, 51).

To avoid overlapping of the single photographed pictures in repetitive cycles, gliding cyclography with the film transported at a constant speed was introduced by Bernshtein (10) and Drillis (20). The need for three-dimensional methods of recording is important. Fischer accomplished it with four cameras, Drillis with two cameras with a 90° angle between the crossing optical axes, and Gilbreth and Bernshtein with one camera and a mirror. Recently at the University of California, three-dimensional recording was accomplished by the use of three synchronized motion-picture cameras and also by one camera and three mirrors. Electrical methods are also used for recording of velocities (tachograph) and accelerations (accelerometer). Motion-picture recording of movements was in favor for a long time, but because data reduction is very difficult and inexact, it now is less often used. For some special motion studies, two- and three-dimensional x-ray motion-picture recording is valuable.

An exhaustive handbook on the technique of chronocyclogrammetry for the investigation of movements was published in 1934 by Popova and Mogilyanskaya (50).

The kinetic analysis investigates how the action of given forces influences the motion of a given body or system. The acting forces and moments can be determined from the curves of linear and angular velocity and acceleration, the force plate records, and the stick diagrams, because the mass of individual body parts can be computed or measured. The statement of the acting forces establishes the conditions and specifications for the work of muscles, the degree of exploitation of the forces of gravity and inertia, and other external forces (ground reaction, air resistance, etc.).

For theoretical work studies, ergograph, ergobicycle, and electroergobicycle are used. A good control is given by studies of metabolism of activity. It permits also determination of the efficiency of work activities.

Applied biomechanics is concerned with the more practical problems of improving movements and positions in industry, sport, military service, art, medicine, and everyday living. It is interested also in the improvement of tools, implements, and equipment as they are related to the operator.

APPLICATIONS

A very important field for the application of biomechanical

analysis is in medicine. A person's movement in the performance of a given activity is an integrated function of the whole body. A knowledge of normal activity patterns is necessary to appreciate the causes or effects of abnormalities. The problem of locomotion can be presented as an example.

The first investigation on normal bipedal locomotion was conducted by E. and W. Weber (64). With very simple equipment they obtained information on some basic and important interrelationships which govern walking. Meyer (45) and Fick (29) tried to analyze walking and standing from the viewpoint of mechanics. Marey (42, 43) in his studies obtained considerable information concerning walking, but did not perform a thorough biomechanical analysis. This was done, however, by Braune and Fischer in their investigation, "Walking of Man," published in six volumes. This may still be considered the best biomechanical analysis of walking. Bernshtein, after investigating the performance of several hundred walkers, came to the conclusion that Fischer's results were in need of correction because of some oversimplifications in the smoothing of curves.

Fischer and Bernshtein adopted the viewpoint that in analyzing walking the consideration of the cycle should be based upon the movement of the center of gravity. A different way of analysis was performed by Elftman (26, 27), who recorded forces between the feet and ground and used these forces as points of departure in the analysis.

The loss of a limb or some other distortion of the body destroys the harmonious functioning of the whole body. This change is reflected as a deviation from the normal patterns of motion. This will apply to locomotion as well. Numerous studies have shown that deviation from the normal pattern of walking is a sensitive indicator of some disease. The studies of Vierordt (63), Steindler (58), Poli (48), and Scherb (54) are notable in this connection.

A general review of the application of biomechanics to orthopedics, traumatology, and prosthetics is given by Nikolayev (47). The methods used in the evaluation of walking with prosthetic legs are described by Amar (3), Du Bois-Reymond (24), Thomsen (62), and Müller (46), as well as in the Reports of the Prosthetic Devices Study of New York University and in the reports and monographs of the Engineering Research Institute of the University of California.

The theoretical bases for the design of artificial limbs are discussed by Schlesinger (55), Schede (53), Schubjé (56), Recklinghausen (52), Bäyer (4), Storck (60), and Kneese (38). The Gilbreths also have contributed to the solution of the problem in their "Motion Study for the Handicapped" (34).

A major application of biomechanical principles occurs in the field of sports. Many authors have reviewed the problems in this field, among whom are Demeny (18), Kotikova (40), and Schuppe (57). The kinematics of sport movements are well described by Knoll (39), and measurements of athletic power are discussed by McCloy (44). Excellent analysis of running and of jumping have been prepared by Bernshtein (13), on running by Fenn (28), and on swimming by Karpovich (37). Most of the publications on the biomechanics of sport can be found in transactions of special institutes and in theoretical journals of sport and physical education.

The biomechanics of music is a comparatively neglected field. Only a limited number of studies are available in this area. Steinhausen was the first to investigate the biomechanics of violin and piano playing. He determined that bowing is essentially a biomechanical problem and correct tone production requires physiologically correct arm motions (59). Polnauer proposes that a perfect violin technique involves the proper biomechanical coordination of the whole body (49). An interesting motion study on violin bowing was made by Hodgson (35), while Bernshtein and Popova have made an excellent study on piano touch and motion form in piano playing (11).

It was noted previously that applied biomechanics in work activities could be dated from man's earliest history. The biomechanics of trade, industry, transport, and communications involves the improvements of work movements, tools, and equipments. It represents the potentially largest area for the application of biomechanical principles.

One of the oldest operations performed by man is the hammer stroke. Since this activity is similar to many other human striking movements used in various trades, it has attracted the attention of several biomechanists. The studies of Fremont (32), Bernshtein (7), Drillis (22), Lange (41), and Derwort (19) are worthy of mention. They studied the motion patterns (motoric gestalt) of this activity and found that a close correlation exists between the motor performance and personality of the operator. Since a motion can be performed in a number of ways, a biodynamical analysis can be made to determine the most efficient method. By such an analysis, the differences in the performance of an activity by different persons can be appreciated and understood. Drillis, in his investigations on nailing, woodcutting, and flax swingling, suggests methods for determining the efficiency of striking movements and also for finding the optimum height of the work place.

The older tools and implements are being superseded by machines. The man-tool combination, and in many instances even the man-machine combination, more and more are being displaced by an entire assemblage of men and machines—"the system." Because of his limitations, the "average man" is not always able to adapt himself to these new conditions. The designers of the machines or the system heretofore have not often considered man's limitations or his capabilities. Dissatisfaction, nervousness, and lowered efficiency are often the results. To provide an efficient and harmonious work environment for the operator, the machine and the system should be designed in accordance with human abilities. They should provide for the limits of human force, speed, accuracy, and endurance with regard to the optimum of work conditions.

Fortunately, there has been an increasing awareness of the need for a systematic approach to the design of the tool, machine, or system. This awareness originated in the military services because of the stressful situations to which military personnel were subjected. The need is being recognized in industry. An increasing number of scientists are being enlisted into these studies. Experimental and industrial psychologists and physiologists are cooperating with engineers in establishing more adequate work situations. The scientific basis for this work depends for the main part on biomechanics.

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NEVANLINNA, R., Eindeutige analytische Funktionen, 2nd revised ed., Berlin, Springer-Verlag, 1953, x + 379 pp. DM 46.50.

BAKER, H. D., RYDER, E. A., and BAKER, N. H., Temperature measurement in engineering, Vol. I, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, vii + 179 pp. $3.75.

MCLACHLAN, N. W., Complex variable theory and transform calculus with technical applications, 2nd ed., New York, Cambridge Univ. Press, 1953, xi + 388 pp. $10.

FLÜGGE-LOTZ, I., Discontinuous automatic control, Princeton, N. J., Princeton Univ. Press, 1953, vii + 168 pp. $5.

RICHARDSON, E. G., Technical aspects of sound, Vol. I, Amsterdam, Houston, New York, London, Elsevier Publishing Co., 1953, xviii + 544 pp.

HEYWOOD, R. B., Designing by photoelasticity, London, Chapman & Hall, Ltd., 1952, xvi + 414 pp. 65s.

BEYER, R., and SCHÖRNER, E., Raumkinematische grundlagen, München, Johann Ambrosius Barth, 1953, 104 pp., 33 figs. DM 9.60.

Letters to the Editor

370. Concerning AMR 6, Rev. 3176 (October 1953): A. I. van de Vooren, Aerodynamic coefficients of an oscillating airfoil with control surface in two-dimensional subsonic flow.

Reviewer expresses his hope that criticism by Fettis and Jordan to the numerical values of the coefficients will be clarified soon, since the tables presented are by far the most complete yet available to the flutter analyst. Author would like to add that controversy has been solved, since a numerical error has been found in his results. Though the original presentation of the theory is correct, a simplified method has been found for determining the pressure singularity at the leading edge. This will be published by Timman in the *J. aero. Sci.* Meanwhile, the numerical error has been eliminated and the new results satisfy the reciprocity relation up to 5 decimal places and are in close agreement with Dietze's results. Corrected tables for the wing

alone are now available and for the wing with flap will soon be available on request at the National Aeronautical Research Institute, Sloterweg 145, Amsterdam (W), Holland.

A. I. van de Vooren, Holland

371. **Concerning AMR 6, Rev. 3599 (Nov. 1953): J. Handin, An application of high pressure in geophysics: Experimental rock deformation.**

Reviewer's name should read R. K. Bernhard, USA.

Theoretical and Experimental Methods

(See also Revs. 394, 401, 425, 426, 429, 432, 441, 452, 528, 533, 543, 547, 548, 622, 655)

372. **McFadden, L., The application of the power series transform to linear difference equations in engineering,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 225, 12 pp., July 1953.

The author illustrates by means of seven examples the utility of an operational calculus of fairly recent origin which has been called both power-series transforms and polynomial transforms. Six of the seven illustrations are typical civil-engineering problems, namely: (1) A continuous beam with n equal spans and a triangular load distribution; (2) the same beam with a uniform load; (3) two vertical columns fixed at their ends and n identical cross beams; (4) a Vierendeel truss with parallel chords; (5) n identical disks attached at equal intervals along a shaft; and (6) the impact of large sphere on a small sphere and the latter rebounding from a wall. Each of these problems is characterized by the fact that the basic relation for the system is a different equation with constant coefficients. The last illustration serves to show that the technique can be used also if the coefficients in the equation are linear. A short table of polynomial transforms is appended to the paper.

Polynomial transforms furnish a powerful numerical method for treating engineering problems and can often be used even if some functions involved in a computation are given in graphical form only. Since these methods are not widely known, the author could have enhanced the utility of his paper if he had given, in addition, a comprehensive bibliography on the subject.

H. M. Trent, USA

373. Gilvarry, J. J., **Approximations in a class of nonlinear vector differential equations,** *Quart. appl. Math.* **11,** 2, 145–156, July 1953.

A three-dimensional quasi-linear approximation to solution of vector differential equation $d^2\mathbf{r}/dt^2 - \mathbf{f}(\mathbf{r}) = \mathbf{b}(t)$ is derived for cases which include $\mathbf{f}(\mathbf{r})$ derivable as gradient of a nonharmonic scalar. Approximation allows correction to zero- or first-order solution for a limited range of t if it is assumed that radius of torsion of an integral curve is slowly varying. Representation of arc length s, s^2, and s^3, as a linear vector function of $\mathbf{r}$, and its subsequent applications are ingenious features of this paper.

Present paper is sequel to AMR **4,** Rev. 2630 in which $\mathbf{f}(\mathbf{r})$ and $\mathbf{b}(t)$ were gravitational and nongravitational accelerations of a particle in two-dimensional motion. S. Kirkby, England

374. **Morgan, G. W., Some remarks on a class of eigenvalue problems with special boundary conditions,** *Quart. appl. Math.* **11,** 2, 157–165, July 1953.

This mathematical paper concerns a problem identical with the Sturm-Liouville problem except for the appearance of the unknown eigenvalue λ in the boundary conditions. A transformation is given by means of which it is possible to eliminate λ from here and thus to apply well-known properties of the Sturm-Liouville theory. Method is extended to higher-order differential equations and, as an illustration, used in three simple examples. The first is related to longitudinal vibrations of a bar with a mass M at one end. The meaning of the transformation here is that M is treated as a part of the bar by making the mass density at this point infinite such that the total mass added equals M. The boundary condition then becomes that of a free end.

M. Kiupers, Holland

375. **Jones, C. W., On reducible non-linear differential equations occurring in mechanics,** *Proc. roy. Soc. Lond.* (*A*) **217,** 1130, 327–343, May 1953.

Purpose of the paper is to present a new method of approach to certain problems in mechanics which give rise to ordinary nonlinear differential equations of the second order. Author shows that Emden's equation $y'' + (2/x)y' + y^n = 0$, occurring in astrophysics, may be reduced in order by taking $X = xy'/y$, $Y = xy''/y'$; the result is $dY/dX = -Y/X \cdot (nX + Y + 3)/(X + Y + 1)$.

Similar transformation is possible for equations in boundary-layer theory, in particular for the equation of Blasius. Therefore, author makes a study of the first-order equation $dy/dx = y/x \cdot (ax + by + c)/(a_1x + b_1y + c_1)$, which is of the type considered by Poincaré. It is convenient to suppose $(bc_1 - b_1c)(ca_1 - c_1a)(ab_1 - a_1b) \neq 0$; in this case the equation has at most seven singular points, of which not more than three are at infinity. The nature of the singularities (nodes, saddles, foci) depends on the six coefficients. The topology of the integral curves provides qualitative information but can, moreover, be a guide for numerical solutions.

O. Bottema, Holland

376. **Washizu, K., Geometrical representations of bounds of eigenvalues,** *J. Japan Soc. appl. Mech.* **5,** 30–31, 159–162, Dec. 1952–Jan. 1953.

Paper presents a geometrical representation for the theorems of Temple and Kato and others on the upper and lower bounds for eigenvalues. It is shown that simple transformations can be used to permit geometrical vector quantity relations for the cases of finite degrees of freedom, including the case of inertial coupling, and can be extended to the Hilbert space with slight modifications.

J. B. Duke, USA

377. **Shnol', I. E., Bounded solutions for a partial differential equation of the second order** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **89,** 3, 411–413, Mar. 1953.

378. **Yakubovich, V. A., Determination of characteristic exponents and criteria of stability for a linear differential equation of the second order with periodic coefficients** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **87,** 3, 345–348, Nov. 1952.

Given the equation $u'' + p(t)u = 0$, where $p(t)$ is periodic, the author obtains various conditions which insure $u = 0(e^{at})$ at $t \to \infty$.

R. Bellman, USA

379. **Mukhin, I. S., On the accumulation of errors in numerical integration of differential equations** (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 753–755, Nov.-Dec. 1952.

The author considers the growth of the error in the step-by-step numerical solution of a differential equation of the second order, comparing three methods: (1) Milne's three-ordinate method for a second-order equation lacking a first derivative; (2) a method of Mukhin, using first, second, and third derivatives; and (3) another method, apparently also due to Mukhin.

using first and second derivatives. The comparison indicates that Mukhin's methods are highly accurate, Milne's quite inaccurate. [Reviewer's note: The calculation was carried to four places in an example for which the methods used are accurate to about eight places. The comparison therefore pertains only to round-off error and sheds no real light on the relative merits of the three methods.]

Courtesy of Mathematical Reviews W. E. Milne, USA

380. Ryabenskiĭ, V. S., Application of the method of finite differences to the solution of Cauchy problem (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **86,** 6, 1071–1074, Oct. 1952.

381. Shtíkan, A. B., Graphical method of solution of some problems of mathematical analysis (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **13,** 177–186, 1952.

By means of examples the author shows how to solve graphically such problems as the integration of functions, solution of ordinary differential equations of first order, systems of such equations, finding an approximate mean value for a derivative, etc. He uses a method called "superposition of coordinates," and another called the "method of straight lines."

Courtesy of Mathematical Reviews W. E. Milne, USA

382. Gagua, M., Values of the best approximation for solutions of some differential equations of an elliptic type (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **86,** 2, 225–228, Sept. 1952.

383. Slobodyanskiĭ, M. G., Value of error of an unknown magnitude in solving linear problems by the variation method (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **86,** 2, 243–246, Sept. 1952.

384. Liebmann, G., Electrical analogues, *Brit. J. appl. Phys.* **4,** 7, 193–200, July 1953.

A review of various direct electrical analogs for solving boundary-value problems. Author treats three types of analog device: (1) "Distributed parameter" (e.g., electrolytic tanks); (2) "lumped parameter" (e.g., resistance networks derived from the "equivalent circuit" concept); (3) network analyzers of the ANACOM variety. Reviewer considers it an excellent review, particularly useful for engineers not previously acquainted with these methods. Copious references to the literature are cited.

C. V. L. Smith, USA

385. Schneider, P. J., and Cambel, A. B., Membrane apparatus for analogic experiments, *Rev. sci. Instrum.* **24,** 7, 513–517, July 1953.

An apparatus for membrane analogy experiments is described which differs essentially from the Griffith and Taylor Model [see "Handbook of experimental stress analysis," John Wiley & Sons, Inc., New York, p. 726, 1950] only in the lateral screw adjustments for positioning the probe. Authors claim that experimental solutions of problems to which the membrane analogy applies can be obtained with an accuracy of $\pm 3\%$, presumably by use of the apparatus described. E. A. Ripperger, USA

386. Ginzburg, B. L., Generalization of various interpolation formulas for a case of unequal intervals (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12,** 201–220, 1952.

This paper gives formulas for interpolation, numerical differentiation, and numerical integration expressed by means of divided differences. Using a notation for divided differences somewhat like Sheppard's notation for central differences in the case of equally spaced abscissas, the author obtains for unequally spaced abscissas the generalizations of Newton's two interpolation formulas. By changes of notation (based essentially on Sheppard's rules) he goes on to get the generalizations of Gauss's, Stirling's, Bessel's, and Everett's formulas. From these, in turn, he gets formulas for numerical differentiation and integration in terms of divided differences.

Courtesy of Mathematical Reviews W. E. Milne, USA

387. Guest, P. G., On the standard errors in the fitting of polynomials to unequally spaced observations, *Austral. J. Phys.* **6,** 2, 131–154, June 1953.

Author considers the problem of fitting "best" polynomials to unequally spaced observations. This problem is much more difficult than is the well-known equally spaced situation. A method of attacking the problem is given. The method is too complicated to describe in this review. Several illustrative examples are worked out in some detail. B. Epstein, USA

388. Timan, A. F., Linear methods of approximation of periodic functions by trigonometric polynomials (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 6, 1147–1150, June 1952.

389. Probability tables for the analysis of extreme-value data, *U. S. Dept. Comm., Nat. Bur. Stands., Appl. Math. Ser.* no. 22, iii + 32 pp., July 1953. $0.25.

Pamphlet presents five tables of functions useful for analysis of extreme-value data. They find application in study of floods and droughts; extreme pressures, temperatures, rainfalls, etc. Another use is found in fracturing of metals, textiles, and other materials under applied force. Introduction gives explanation and use of tables together with an example dealing with floods. An excellent bibliography lists articles dealing with applications.

Y. Luke, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 373, 375, 400, 407, 517)

390. Vening Meinesz, F. A., The second-order corrections for pendulum observations at sea, *Proc. k. Ned. Akad. Wet. (B)* **56,** 3, 218–227, May/June 1953.

Paper examines second-order corrections for pendulum observations at sea arising from accelerations of observing equipment. Types of accelerations considered are: (a) $\ddot{x} = \xi\cos(\omega t + \phi_x)$, vertical; (b) $\ddot{y} = \eta \sin(\omega t + \phi_y)$, horizontal, in swinging-plane of pendulums; (c) $\ddot{z} = \zeta\sin(\omega t + \phi_z)$, horizontal, at right angles to (a) and (b). Formulas for $\delta g/g$ are derived for (a), (b), and (c) in terms of ξ, η, ζ, respectively, and in terms of ratio ϵ of pendulum-period to period $2\pi/\omega$ of disturbing acceleration. Investigation shows Browne's formula

$$\delta g/g = -\frac{1}{8}(\xi/g)^2 + \frac{1}{4}(\eta/g)^2 + \frac{1}{4}(\zeta/g)^2$$

to be satisfactory, provided ϵ^2 can be neglected. In subsequent discussion, author gives three conditons which need to be fulfilled in pendulum observations at sea. K. E. Bullen, Australia

391. Bowden, F. P., Friction on snow and ice, *Proc. roy. Soc. Lond. (A)* **217,** 1131, 462–478, May 1953.

Paper gives results of experiments to measure coefficient of static and dynamic friction of metals, synthetic polymers, and waxes on snow and ice. Full-size and scale models of ski were

used, and tests were conducted at various temperatures. Tendency of the ski surface to be wet by water was also investigated.

On cold snow, the friction is relatively great statically and slightly less at low velocities. At appreciable velocities, the friction is much less because of a water film formed by frictional heating. Friction tends to be great when the ice or snow is harder than the engaging surface. Polytetrafluoroethylene gives relatively low friction on ice and snow under all conditions investigated. C. E. Crede, USA

392. **Serebrennikov, M. G., Profile of a cam mechanism with a flat thrust gear** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12,** 23–36, 1952.

393. **Kurovskiĭ, F. M., Calculating the motion of a driven link of a mechanism** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12,** 37–43, 1952.

394. **Slezkin, N. A., Differential equations for the movement of pulp** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86,** 2, 235–237, Sept. 1952.

395. **Khodzhaev, L. Sh., Generalized Newtonian potential of an unbound mass** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86,** 5, 893–896, Oct. 1952.

396. **Sapa, V. A., Some cases of motion of a cylinder rotating about its axis** (in Russian), *Izv. Akad. Nauk Kazakh. SSR* 1951, no. 62, *Ser. Mat. Mekh.* 5, 154–167, 1951.

Consider the motion of a cylinder revolving about its axis and subjected to a translation whose initial velocity is perpendicular to the direction of the axis of the cylinder. Such a cylinder is then acted upon, in addition to the forces of gravity and resistance (assuming that the Newtonian square law holds, i.e., the resistance is proportional to the square of the linear velocity), by the Magnus force. The author considers only the cases when the equations of motion of the center of mass of the cylinder can be integrated in finite terms. In particular, he studies two cases: the axis of the rotating cylinder is (1) horizontal and (2) vertical. In case (1) the following subcases are considered: (a) The resistance force is in comparison with the force of gravity and the Magnus force, and (b) the resistance force is small in comparison with the Magnus force, and the modulus of the difference between the Magnus force and the resistance is small in comparison with gravity. In case (2) the subcases considered are (a) as in case (1), and (b) the resistance, small in comparison with the Magnus force, is comparable to the force of gravity. The graphs of the trajectories described by the center of mass of the cylinder are sketched for various initial conditions. E. Leimanis, Canada

397. **Sokolov, Yu. D., Singular trajectories of a system of free material points** (in Russian), Monograf. Instituta Matematiki, vyp. I. Akad. Nauk Ukrain. SSR, Kiev, 1951, 126 pp. 6 rubles.

For the qualitative treatment of dynamical questions, investigation of singular points and singular trajectories of equations of dynamical origin is of the highest importance. Author considers the singular trajectories of a system of n (≥ 3) particles P_i of masses m_i ($i = 1, 2, \ldots, n$), which attract or repel each other, the interaction between P_i and P_j ($i \neq j$) having magnitude $m_i m_j |f(r_{ij})|$ and representing an attraction or repulsion according as f is negative or positive. It is assumed that $f(r)$ is analytic for positive r and may have singularities at the points $r = 0$ and $r = \infty$ on the real axis.

The monograph consists of four chapters. Chap. I contains some general remarks concerning the regular motion of the system and the singularities of the integrals of motion. In chap. II, trajectories of double collision ($\lim_{t \to t_1} J^2 = J_1^2 > 0$, where J^2 is the moment of inertia of the system about its center of mass) in the generalized bodies problem are considered, assuming that

$$\lim_{r \to 0} r^{2\alpha+1} f(r) = -2\alpha < 0 \qquad [1]$$

Chap. III is concerned with trajectories of general collision ($\lim_{t \to t_1} J^2 = 0$) under the assumption [1]. Finally, chap. IV deals with the case when the particles recede indefinitely far from each other ($\lim_{t \to t_1} J^2 = \infty$). It is assumed that $f(r)$ is analytic for positive r, continuous for $r = 0$, and increases indefinitely as $r \to \infty$ in such a way that $\lim_{r \to \infty} r^{1-2\beta} f(r) = 2\beta > 0$.

With the publication of this monograph, a certain period of work (1934–1951) of the author on the problem stated in the beginning may be considered as finished. E. Leimanis, Canada

Gyroscopics, Governors, Servos

(See also Revs. 565, 636)

398. **Cohen, G. H., and Coon, G. A., Theoretical consideration of retarded control,** *Trans. ASME* **75,** 5, 827–834, July 1953.

Paper is a study of the control of a process, the reaction curve of which can be represented by a dead period and a single first-order lag term. The controller is assumed to be of the proportional type with reset and derivative responses available. The characteristic differential equation of the over-all control loop is used to plot a control region which the authors define as a family of curves relating the adjustable control parameters for a given degree of stability of the process. Stability is defined in terms of the amplitude ratio of the fundamental harmonic mode. Authors suggest analytic relations for the determination of controller settings. Paper should be of considerable interest to anyone in the process-control field. S. Z. Dushkes, USA

399. **Pessen, D. W., Optimum three-mode controller settings for automatic start-up,** *Trans. ASME* **75,** 5, 843–848, July 1953.

Author used electric analog to represent starting-up industrial processes and to study response of controlled variable under automatic control by three-mode controller. From a large number of tests with different controller settings an empirical formula is obtained which is claimed to give suitable settings to prevent the controller available overshooting the set point, while giving approximately optimum response to process load disturbances. Author presents typical records showing satisfactory start-up and response curves given by the process analog when settings were calculated by his formula. Finally, author suggests simple rule for maximum amount of dead time that can be tolerated in a process which is to be started up on automatic control without overshooting. E. Giffen, England

400. **Ersov, B. A., On stability-in-the-large of a certain system of automatic regulation** (in Russian), *Prikl. Mat. Mekh.* **17,** 1, 61–72, Jan.-Feb. 1953.

The action of a certain automatic regulator is governed by a system

$$\dot{x} = -Nax - by + \varphi(x, y)$$
$$\dot{y} = f(cs - dy) = cx - dy + \psi(x, y)$$

where a, b, c, d, are positive constants, and φ, ψ are the non-linearities, $N = 1, 0, -1$, depending on whether the system has positive self-correction, none, or negative self-correction. It is very clearly indicated that there is no limit-cycle, since the critical point at the origin appears to be the only one present and is stable as both x and $y \to 0$ as $t \to +\infty$. [Reference: Erugin, N. P., AMR 4, Rev. 2348.] S. Lefschetz, USA

401. Koshlyakov, V. N., On certain particular cases of integration of Euler's dynamical equations, connected with the motion of a gyroscope in a resisting medium (in Russian), *Prikl. Mat. Mekh.* **17**, 2, 137–148, Mar.-Apr. 1953.

Suppose that the equatorial moments of inertia A and B of a gyroscope differ only slightly from each other, that $B > A$, and that the axial moment $C > A$. Further assume that the components of the moment generated by the resistance forces are $-\lambda Ap$, $-\lambda Bq$, $-\lambda Cr$, where λ is some coefficient of proportionality and p, q, r are the components of the angular velocity of the flywheel. A solution of the Eulerian equations is sought in the form of power series in terms of the small parameter $\epsilon = (B - A)/C$. The method of successive approximations is applied in such a way that the zero approximation corresponds to the symmetric case, when $A = B$.

In the case of a symmetric gyroscope ($A = B$) and under the assumption that the moment of the resisting forces is of certain particular forms, the Eulerian equations are integrable in terms of Bessel functions and a degenerate hypergeometric function. Furthermore, it is shown that, if the angular velocity of the flywheel decreases in such a way that the moment of the resisting forces can be considered as varying proportionally to the first or to the second power of the angular velocity, the equation determining the angle of rotation of the inner Cardan ring can be integrated in terms of Bessel functions of zero order or cylindrical functions, respectively [see also Koshlyakov, *Inzhener. Sbornik, Akad. Nauk SSSR* **6**, 1950]. E. Leimanis, Canada

402. Sretenskii, L. N., Motion of the Goryachev-Chaplígin gyroscope (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 1, 109–119, Jan. 1953.

The problem of motion under gravity of a body, one of whose points O is fixed, has been solved by Euler (when the fixed point O is the center of gravity of the body), Lagrange (when two of the principal moments of inertia at the point O are equal, i.e., $A = B$, and the center of gravity lies on the third axis of inertia of the body), and Mme. Kovalevskiĭ (when $A = B = 2C$ and when, further, the center of gravity is situated in the plane of the equal moments of inertia). In each of these cases the general solution contains five arbitrary constants of integration. Goryachev [*Mat. Sbornik* **21**, 431–438, 1889] showed that the problem is also solvable when $A = B = 4C$, the center of gravity is in the plane of equal moments of inertia at O, and when, further, the angular momentum about the vertical through O is zero. In this case the solution contains three arbitrary constants. Finally, Chaplígin [*Trav. Soc. Imp. Nat. Mosc.* **10**, fasc. 2, 31–34, 1899 = Collected Works, Moscow-Leningrad, Izd. Tekh. Teor. Lit., 1948, vol. I] showed that, under the assumptions made by Goryachev, another particular integral exists, and hence there exists a solution depending upon four arbitrary constants.

Let the line through the fixed point O and the center of gravity be taken as the Ox-axis, and let the center of gravity be at the distance α from O; let the Eulerian angles ϵ, ω, φ, which define the position of the principal axes of inertia $Oxyz$ with reference to fixed rectangular axes $OXYZ$, of which the axis OZ is vertical, be defined as follows: ϵ is the angle between the axes OZ and Ox, ω is the angle between OX-axis and the line of intersection $O\gamma$ of the planes XOY and yOz, and φ is the angle between $O\gamma$ and Oy-axis. Further, let p, g, r be the components along the axes $Oxyz$ of the angular velocity of the body, and let P be its weight.

The author investigates the motion of the Goryachev-Chaplígin gyroscope assuming that initially: (1) The axes OX and Ox coincide, while the axes Oy and Oz make with the axes OY and OZ, respectively, an angle θ_0, and (2) that a large spin is given about the Ox-axis to the body, i.e., $p = p_0$, $g = r = 0$, where p_0 is large. The results obtained may be summed up as follows: The amplitudes of the oscillations of $\cos \epsilon$ vary in such a way as to produce beats. The period of the beats is $4\pi p_0/3a$, while the period of the small oscillations, constituting the beats, is π/p_0, where $a = P\alpha/C$. The axis of the gyroscope, performing the above-mentioned oscillations, passes through the equatorial plane of the fixed sphere of radius one described about O at times $t_n = 4p_0/3a\ (n\pi - \lambda \sin \theta_0)$, $t_m = 1/p_0\ (m\pi - \theta_0)$, where $\lambda = a/2p_0^2$ and $n, m = 0, \pm 1, \pm 2, \ldots$

At each of these instants, the angle changes the sense of its variation, i.e., it passes from an increasing angle to a decreasing one, and conversely. In addition, ω attains its relative extremum values at times $t_n' = t_n + 4\pi p_0/6a$.

The angle φ varies almost proportionally to the time with velocity p_0 near the instants t_n, when the axis of the gyroscope is horizontal. Near the instants of time corresponding to maximum inclinations of the axis of the gyrscope to the equator of the fixed sphere, the angle φ changes the sense of its variation.

E. Leimanis, Canada

403. Braunbek, W., The symmetrical gyroscope with harmonically variable directing moment (in German), *ZAMM* **33**, 5/6, 174–187, May/June 1953.

The motion of a symmetric gyroscope is investigated, if a constant and a harmonically variable directing moment are acting at the axis. If the directing moment is generated in such a way that a homogeneous magnetic field acts on a bar magnet that is situated in the axis, two cases are to be distinguished, namely, that the alternative field is situated parallel and normal to the constant field. There is resonance in the first case, if the frequency of the alternative field is equal to that of the free nutation; in the second case, if that frequency is equal to that of the free precession of the gyroscope. Moreover, subharmonic resonances are possible. From author's summary

404. Fridlender, G. O., Precession of a gyroscope under the effect of an external force (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12**, 229–233, 1952.

Vibrations, Balancing

(See also Rev. 573)

405. Eastwood, W., The factors which affect the natural frequency of vibration of foundations, and the effect of vibrations on the bearing power of foundations on sand, Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953 (in 3 vols.), vol. I, 118–122. SFr. 75.

Factors which affect the natural frequency of vibration of foundations have been under investigation for the past 20 years. In this connection, works of Crockett and Hammond, Tschebotarioff, and others in Russia have thrown some light, which unfortunately has given contradictory results, due to limited range of full-scale tests which can be made and to difficulty in controlling soil conditions under full-scale foundations. Author has made certain tests to elucidate further the results described in this paper.

Laboratory test findings reveal that, for lightly loaded footings on sandy soil, frequency is independent of footing size, while for

large loads, it is inversely proportional to footing width. Also, square footings give higher frequencies than rectangles of same width, but lower than circles of same width. Effects of vibration on bearing power and settlement were also studied, and useful results obtained both for ordinary and inundated soils. It is shown that, in the latter case, inundation reduces damping effects. Thus a given impressed force tends to cause greater vibration than on dry sand, although the exuberance will also depend largely in each case on incidence of resonance.

S. K. Ghaswala, India

406. **Koch, H. W., Determination of effect of structural vibrations** (in German), *ZVDI* **95,** 21, 733–737, July 1953.

In dealing with structural vibrations a distinction must be made between the effects on the structure and those on persons within it. So far as the structure is concerned there are two approaches: (a) Direct measurement of strains in members or of deflection curves and frequencies, in each case allowing determination of actual stresses. (b) Indirect assessment of the damaging power of a vibration by means of an empirical criterion and comparison with observations. At the Curt-Risch Institute of the Technische Hochschule, Hannover, some years ago, there were devised empirical scales for degree of structural damage in terms of the quantity (square of amplitude) times (cube of frequency). These apply to structures of standard types and in good condition. With regard to the effects of vibrations on people, it is found that this quantity defined above is not, by itself, a criterion but varies with frequency for a constant effect. For this reason it is obvious that a person's reaction to a structural vibration is not a measure of its effect on the structure. M. P. White, USA

407. **Desoyer, K., and Slibar, A., Contribution to the calculation of pendulous vibration absorbers** (in German), *Ing.-Arch.* 21, 3, 208–212, 1953.

Centrifugal pendulums can be used for reducing quick periodic vibrations in the speed of rotating masses. It is known from linearized theory that the pendulum should be designed in agreement with a tuning condition in order that disturbances of a certain frequency are completely damped. This condition gives a relation between geometric dimensions, but pendulum mass remains arbitrary. Authors show that, if nonlinear terms originating from Coriolis force are taken into account, damping is no longer complete but becomes maximum for a certain value of the pendulum mass. For a mass equal to twice this value, the coefficient of the quadratic term in the response becomes infinitely large, thus leading to undesirable resonance phenomena.

Reviewer remarks that neglect of vibration in rotational speed is only justified in the nonlinear equations if the tuning condition is satisfied, since this variation then vanishes in first approximation. A. I. van de Vooren, Holland

408. **Jarrett, G. W., and Warner, P. C., The vibration of rotating, tapered-twisted beams,** *J. appl. Mech.* **20,** 3, 381–389, Sept. 1953.

Extends Myklestad's adaptation of the Holzer method to calculate frequencies and mode shapes for tapered-twisted beams with elastic constraints. Coupling between torsional and flexural vibrations is not considered. Numerical example is given for a long turbine blade. Computed frequencies are within 8% of test values for first four modes. A. I. Bellin, USA

409. **Saibel, E., and D'Appolonia, E., Forced vibrations of continuous beams,** *Trans. Amer. Soc. civ. Engrs.* **117,** 1075–1086, 1952.

Complete determination of forced oscillations of a continuous beam is presented by developing the solution for the nonhomogeneous forced problem in terms of the known eigenfunction of the same freely vibrating beam with all of the intermediate supports removed (the simple beam with the same end conditions). Lagrangian equations are used to obtain the equations of motion with the intermediate supports being introduced through undetermined multipliers. Method is ingenious and should be applied to other one-dimensional problems in which there is indeterminacy of this type. Paper includes a numerical example of two-span continuous beam with sinusoidal driving force.

H. G. Cohen, USA

410. **Lubkin, J. L., and Luke, Y. L., Frequencies of longitudinal vibration for a slender rod of variable section,** *J. appl. Mech.* **20,** 2, 173–176, June 1953.

See AMR **6,** Rev. 1815.

411. **Naake, H.-J., Experimental investigation of the vibration of rails** (in German), *Akust. Beihefte* **1,** 139–147, 1953.

The vibrations of rails have been investigated under different conditions. Measurements have been made with sinusoidal excitation of rail pieces suspended by steel wires, both at a test track 7 m long and at a ready-laid track; in addition, the vibrations excited in a rail by a train moving along the track have been measured. At the rail suspended by steel wires, the measurements showed the course of the phase velocity against frequency for all sorts of vibrations present up to a frequency of 10 keps. At the test track and at the ready-laid track the measurements have been extended over the frequency range from 200 cps to 80 keps. From the measurements of the noise caused by the moving train, the value of the acceleration and the frequency spectrum of the rail vibrations have been calculated.

From author's summary

412. **Bondar', N. G., Frequency of plane, free, and continuous vibrations of jointless, parabolic, and chain arches of a varied cross section** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **11,** 181–186, 1952.

413. **Gustafson, P. N., Stokey, W. F., Zorowski, C. F., An experimental study of natural vibrations of cantilevered triangular plates,** *J. aero. Sci.* **20,** 5, 331–337, May 1953.

Results are obtained for lowest six frequencies of triangular plates of uniform thickness clamped on one edge. Two families are studied: (1) Delta-wing planform of fixed span with various root chords; (2) fixed-span and fixed-root chord with various sweepback angles. A. I. Bellin, USA

414. **Kumai, T., Flexural vibration of the square plate with a central circular hole,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **1,** 4, 123–129, Dec. 1952.

Flexural vibrations of the clamped and simply supported square plate with a central circular hole are observed experimentally, and the frequencies of the plates with different diameter of hole are measured up to the second mode of nodal vibrations by the method of Chladni figure. An analytical solution is presented which consists of the superposition of the solutions of circular ring plate satisfying the boundary conditions at several points along the outside edges of the square plate. The analytical results appear to be in good agreement with the experimental results.

P. G. Jones, USA

415. **Haag, J., Nonlinear vibrations in chronometry** (in French), *Publ. sci. tech. Min. Air, Paris,* no. 281, 1–14, 1953.

416. Kulikov, N. K., Approximate determination of the period of free vibrations of a nonlinear system with one degree of freedom (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **13,** 187–189, 1952.

417. Liu, H.-C., Contribution to the theory of free vibration of ideal liquids in communicating tubes (in German), *ZAMP* **4,** 3, 185–196, 1953.

Author considers the vibrations of ideal fluid under gravity in a bent tube of nonconstant cross section. If the velocity is assumed constant over every cross section of the tube, then the motion of the free surface at each end is given by an ordinary nonlinear differential equation. This can be solved by elliptic functions when the cross sections at the two ends of the fluid column are constant but not necessarily equal, and then the displacement-time curve departs more and more from the simple harmonic form as the amplitude of displacement is increased. This is illustrated by curves. Reviewer notes that author's earlier papers on this subject [AMR **6,** Revs. 1937, 1938] are not referred to. In the former of these he obtained the same equation, an elastic spring supplying the restoring force. The parametric values underlying the computed curves are not given, and practical utility of the curves is thus reduced to the vanishing point.

F. Ursell, England

Wave Motion, Impact

(See also Rev. 527)

418. Kolsky, H., Stress waves in solids, Oxford, at the Clarendon Press, 1953, x + 211 pp.

Basic theory of elastic wave propagation developed in the 19th century has engineering as well as seismological applications, and part I (98 pp.) deals with the former in relation to electronic excitation and measurement of waves and pulses, interpretation of records as to dynamic properties of old and new materials. For this, the elementary theory of longitudinal, torsional, and flexural waves in bars is not adequate. A short account is given of the principal standard theory of elastic body and surface waves, reflection and refraction, Pochhammer waves in circular cylinders with curves of wave, and group velocity vs. wave length. Elementary flexure-theory corrections for rotatory inertia and shear and elementary treatment of longitudinal motion in the conical bar are included. A summary of results is given for readers omitting the analysis. A chapter on experiments on elastic bars, 1914 to 1950, gives substantiation of the theory.

Part II is 98 pp. on imperfectly elastic media. Theory is in terms of spring-dashpot combinations, Boltzmann superposition as to "memory" effects, and propagation in a viscoelastic bar. Variety of mechanisms responsible for internal friction is examined with regard to experiments. The chapter on experimental investigation of dynamic material properties covers methods of free vibration, resonance, wave propagation (including photoelastic records) and direct recording of stress-strain curves. Theory of plastic waves in bars is given, with related experiments. Short final chapter on fractures due to stress waves has photos with interesting interpretations by reflections.

This small volume is a pioneer in its interweaving of theory and experiment, elastic and inelastic, relative to engineering questions. Books and papers referred to include 86, dated 1940–1950.

J. N. Goodier, USA

419. Bordoni, P. G., and Nuovo, M., Velocity measurements for elastic waves in solids at elevated temperatures (in Italian), *Ric. sci.* **23,** 4, 593–599, Apr. 1953.

The frequency of fundamental resonance of a small cylinder is measured by an electroacoustic method, described in a preceding paper, for five pure metals (Pb, Su, Bi, Al, Cd) at elevated temperatures up to the vicinity of the fusion point. The logarithmic derivation with temperature of the velocity of wave propagation, calculated from the experimental results, is compared with the behavior of cubic dilatation. W. Wuest, Germany

420. Walsh, J. M., Shreffler, R. G., and Willig, F. J., Limiting conditions for jet formation in high velocity collisions, *J. appl. Phys.* **24,** 3, 349–359, Mar. 1953.

Extremely violent collision between solids, resulting in high-speed jet formation, has successfully been treated as a problem in classical hydrodynamics [AMR **1,** Rev. 1300]. Author has taken a step further using gas dynamic theory. At sufficiently small angles between the colliding surfaces and supersonic velocities, a jetless configuration is postulated and clearly described by the shock polar. The critical angle of deflection, well-known in gas dynamics, is here the limit between jet-forming and jetless collision configuration. Experiments with metal plates driven by high explosives are described, both wedge-type collisions (constant collision angle) and angle-variation collisions. Observations with a smear camera capable of writing speed 3.2 mm/μsec and a framing camera with a time resolution of 0.9μsec verify the theoretical predictions within the uncertainties of measurement and equation-of-state data for the metals.

G. Huss, Sweden

421. Longuet-Higgins, M. S., On the decrease of velocity with depth in an irrotational water wave, *Proc. Camb. phil. Soc.* **49,** part 3, 552–560, July 1953.

Variations of velocity, pressure, and "mass-transport" velocity of any periodic or solitary wave are investigated theoretically. Treatment allows the following main conclusions: (1) With infinite depth, pressure fluctuations do not, in general, tend to zero with depth; (2) with uniform depth, "mass-transport" velocity decreases with depth. Experiment contradicts (2), but this is attributed to rotational effects. R. N. Arnold, Scotland

422. Greene, T. R., and Heins, A. E., Water waves over a channel of infinite depth, *Quart. appl. Math.* **11,** 2, 201–214, July 1953.

Paper gives the mathematical solution for gravity waves over a submerged semi-infinite plane barrier in water of infinite depth. Thus it constitutes the limiting case (requiring other mathematical methods) of a more general problem discussed by Heins [AMR **3,** Rev. 1851]. H. Lundgren, Denmark

423. Kopzon, G. I., Two-dimensional impact in a slightly compressible ideal fluid (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 719–722, Nov.-Dec. 1952.

424. Ludloff, H. F., and Friedman, M. B., Diffraction of blasts by axisymmetric bodies, *J. aero. Sci.* **19,** 6, 425–426, June 1952.

Diffraction pattern for shocks strong enough to produce supersonic flow over slender bodies is obtained from retarded potential solution of wave equation. Pressure and density fields are presented for a 5.7° cone in flow at $M = 1.21$. Rotational flow exists only behind the Mach stem and no slipstream is predicted. Unfortunately, authors omitted explicit form of several parameters and functions. In common with other linearized theories there is a problem of interpreting the results for finite bodies. Ting and Ludloff [AMR **4,** Rev. 3608] previously applied the method to two-dimensional flow over a wedge and obtained good agreement with White's shock-tube data [AMR **5,** Rev. 1133]. W. Griffith, USA

Elasticity Theory

(See also Revs. 418, 419, 438, 439, 444, 445, 448, 451, 453, 457, 465, 470)

425. **Boley, B. A., Graphical-numerical solution of problems of Saint-Venant torsion and bending,** *J. appl. Mech.* **20,** 3, 321–326, Sept. 1953.

A simple successive-approximation procedure for the solution of the problems of Saint Venant torsion and bending of beams of arbitrary cross section is presented. The shear stresses in a cross section of the beam are first calculated from the formulas valid for thin-walled sections, on the basis of an assumed set of lines of shearing stress. From these a first approximation to the stress function of either the torsion or the bending problem is found. The second approximation to the stress function is then obtained from the governing equation of the problem, expressed in finite-difference form; this, in turn, allows the determination of an improved set of lines of shearing stress, and hence of the shearing stress itself. The procedure can be repeated until the results of two successive steps are sufficiently close. Applications are presented for a beam cross section for which the exact solutions are known, and it is shown that no further difficulties arise in applications to more complicated shapes. From author's summary

426. **Chatterjee, P. N., A numerical method for analysis of two-hinged elastic arches by deflection theory,** *J. Instn. Engrs. (India)* **33,** 2, 125–161, Dec. 1952.

Paper (a condensation of author's doctorate dissertation, University of Illinois, 1949) derives very clearly a trial-and-error method of applying deflection theory to two-hinged arches and, as well, derives an approximate theory which is simple to apply. Both theories were checked by the author, using a small steel arch rib of rectangular sections at the Bengal Engineering College, India. He reports good agreement, even using the approximate analysis.

Some years ago the reviewer—using same method of analysis as author's approximate method—investigated a spectacular collapse of a large wooden lamella arch roof in Vancouver, Canada, and found, as the cause of failure, deflection effects under a one-sided snow load. Span of arch was 127 ft and depth 16 in.

Author's trial-and-error approach renders such variables as changing rib section and loads to be considered and is consistently realistic. A. H. Finlay, Canada

427. **Torre, C., Relations between the characteristics and a contact transformation** (in German), *Öst. Ing.-Arch.* **7,** 1, 32–38, 1953.

Papers deal with the similarity of solutions obtained in the problem of the limit solicitation, starting from Mohr's envelope or by the characteristic values of a linear equation of second order in partial derivatives. Generalization of that can be done by finding some "aequatio directrix" for the contact transformation, which solutions must agree identically with the characteristics of the general equation of second order. Starting from the invariants of a plane stress state

$$J_1 = \sigma_x + \sigma_y = \sigma_1 + \sigma_3; \quad J_2 = \sigma_x\sigma_y - \tau_{xy}^2 = \sigma_1\sigma_3$$

and based on the equation

$$W = \sigma^2 + \tau^2 - \sigma J_1 + J_2 = 0$$

that expresses the aequatio directrix of stress circle in terms of invariants, an expression for Mohr's envelope in terms of σ_1, σ_2, and $tg\varphi$ follows. Author compares the theoretical curve with the numerical values of Roš and Eichinger tests, finding agreement in the compression zone, while it differs considerably for the tension one.

Author concludes that mathematical expressions of the limit curve can be recommended only where a compressive stress state is dominant. E. D. Fliess, Argentina

428. **Wasiutynski, Z., On the hypothesis of J. Bernoulli** (in Polish), *Arch. Mech. stos.* **4,** 93–103, 1952.

The paper treats the possibility of a generalization of the hypothesis due to J. Bernoulli (1705) on the linearity of stress distribution in a plane transversal section of a perfectly elastic bar in pure bending. The author proposes to generalize the said hypothesis based on two presumptions: First, the reversibility of nonlinear elastic strains; second, either the uniqueness of nonlinear solutions, or the principle of minimum strain energy in the position of elastic equilibrium. The second of these presumptions must replace Hooke's law, valuable for linear elastic materials. Based on the latter version of the second hypothesis, author demonstrates several simple examples of compression-bending stress distributions for materials having variable moduli of elasticity $\sigma:\epsilon = E(\epsilon)$, given as functions of strain ϵ.

J. Naleszkiewicz, Poland

429. **Craemer, H., Dependence of the strength of test specimens on their size, considered on the basis of theory of probability (translated by J. C. van Tienhoven),** *Wwys. Exp. Sta. Transl.* no. 53–5, 25 pp., June 1953.

Author develops theory of strength based on theory of probability, paralleling the theory by Weibull [*Proc. roy. Swedish Inst. Engng. Res.*, Stockholm, 1939]. Conclusions based on theory are: (1) Larger test specimens have lesser standard deviations. (2) Longer test specimens have lesser mean strengths. (3) In brittle material, increase in cross section has the same effect as increase in length, but in plastic materials the mean strength remains unchanged. (4) The practical minimum strengths depend only slightly upon the size of structural members.

Data from concrete cylinder tests are analyzed to substantiate the conclusions. D. E. Hardenbergh, USA

430. **Das, S. C., On the elastic distortion of a cylindrical hole by localized axial shears on the inner boundary,** *Indian J. theor. Phys.* **1,** 1, 41–46, June 1953.

Author gives a solution for the state of stress in the neighborhood of a cylindrical hole in an infinite elastic solid, loaded by axial shearing forces, which act over a narrow region. Such stresses can, for instance, be produced by a piston. The integration of the elastic equations with regard to the boundary conditions is obtained by means of parameter integrals.

H. Neuber, Germany

431. **Karunes, B., On the concentration of stress round the edge of a hole bounded by two intersecting circles in a large plate,** *Indian J. Phys.* **27,** 4, 208–212, Apr. 1953.

A stress function in bipolar coordinates has been obtained to give the distribution of stress round the edge of a hole bounded by two intersecting circles in an infinite plate under uniform shear in the plane of the plate; and some particular cases are discussed. From author's summary

432. **Kitover, K. A., Use of special systems of biharmonic functions for solving certain problems in the theory of elasticity** (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 739–748, Nov.–Dec. 1952.

433. **Okubo, H., The stress distribution in an aeolotropic circular disk compressed diametrically,** *Rep. Inst. high speed Mech., Tōhoku Univ.* **3,** 11–22, Mar. 1953.

Author obtains the exact solution of the two-dimensional prob-

lem for an arbitrary orientation of the direction of compression when the axes of symmetry are at right angles in the plane of the disk. The stress components are obtained as infinite series after a suitable transformation of coordinates. As an example, the stress distribution in a disk of oak wood is evaluated numerically for three directions of compression. Comparison with the solution for an isotropic disk shows that the distribution of normal stress on the radii is not affected appreciably by the aeolotropy, while shearing stresses are. Referring to earlier work, author concludes that the stress distribution in an aeolotropic square plate can be obtained approximately by considering a circular disk under cognate boundary conditions.

F. DiMaggio, USA

434. Sokolov, L. D., Criterion of stress in a diagram of mechanical deformability (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **87,** 6, 905–908, Dec. 1952.

435. Mikeladze, M. Sh., Rigidity of a rapidly rotating cylinder (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 706–710, Nov.-Dec. 1952.

436. Manson, S. S., Behavior of materials under conditions of thermal stress, "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 9–76, 1953.

Author begins by summarizing in a simplified and lucid manner the theory of thermal stresses in a flat plate. In the limiting cases of very thick plates and of very thin plates, the resistance to shock depends on different combinations of the material constants. Test techniques must, therefore, be adapted to the actual working situation. This is illustrated by practical examples. In cases where the principal thermal shock occurs by surface heating, the surface stresses are compressive and do not cause fracture. The conditions for obtaining minimum tensile stress within the specimen differ from those for obtaining minimum surface stress.

For ductile materials, failure occurs not in one cycle but by fatigue. Author discusses briefly the very complicated interactions of fatigue, work-hardening, and annealing with or without stress. Experimental methods are described, with special emphasis on components and materials for gas turbines. Special techniques, such as the avoidance of stress concentrations and constraints, the use of protective and stressed coatings, and of clad metals, are discussed. F. R. N. Nabarro, England

Experimental Stress Analysis

(See also Revs. 385, 418)

437. Hiltscher, R., Photoelastic investigation of elastoplastic states of stress (in German), *ZVDI* **95,** 23, 777–781, Aug. 1953.

The diphase artificial resin, Polystyrol, is suggested as a medium for the study of the effects of plasticity in materials such as low-carbon steel. Photographs of the isochromatics resulting from the loading of straight beams, a notched bar, and a die pressed against a "half space" are reported. The technique is similar to that of conventional two-dimensional photoelasticity except that (1) the plastic region must be in compression, and (2) even in uniaxial stress the order of an isochromatic is a function of time as well as of the stress level. Calibration curves are obtained by means of an "artificial device," which the author does not reveal. In biaxial states of stress the isochromatics represent lines of equivalent flow conditions, and it is possible to use Polystyrol to study the growth of the plastic region and its influence on the elastic part of the stress distribution.

Reviewer feels that the use of plastics in connection with inelastic effects in metals must be viewed with some reserve. Metals are aggregates of crystals and most of their important properties derive from this fact. So long as behavior may be regarded as elastic and the crystals so small as to render the prototype statically homogeneous and isotropic, plastic models may be used with confidence. The state of (two-dimensional) stress is in most cases entirely independent of the elastic constants of the material. When inelastic effects are encountered, this independence, for one thing, generally disappears.

Diphase resins such as Polystyrol may, however, serve a useful purpose in verifying solutions governing the state of stress in hypothetical "ideally plastic" materials. In this regard, the time dependence of the inelastic effect in Polystyrol appears to the reviewer to represent obstacles to quantitative work, at least as compared with the nylon copolymer reported by Hetenyi [AMR 6, Rev. 2769]. L. E. Goodman, USA

438. Dose, A., and Landwehr, R., Determination of lines of equal principal stress sum by means of interference of equal thickness (in German), *Ing.-Arch.* **21,** 2, 73–86, 1953.

Authors describe method giving complete isopachic pattern providing loci of constant sum of principal stresses in plate with plane state of stress. Combination with photoelastic stress pattern gives complete stress distribution. Method due to Fabry [*C.R. Acad. Sci.* **190,** 457–460, 1930], using interference fringes caused by reflection at the two surfaces of glass model, was modified. When model is strained, its thickness and fringe pattern change. Instead of glass with relatively high ratio of photoelastic fringe value to isopachic fringe value, Plexiglas with a ratio of about 1 to 50 was used. Thus, double refraction caused by stress could be neglected and, by combining fringe patterns for stressed and unstressed model, complete isopachic pattern could be made directly visible.

Detailed description of alternative methods is given by Frocht [AMR **1,** Rev. 602]. Reviewer believes that accuracy and simplicity of method described are not up to those achieved by means of recent applications of photoelastic methods.

S. Sjöström, Sweden

439. Durelli, A. J., Lake, R. L., and Phillips, E., Stress distribution in plates under a uniaxial state of stress, with multiple semicircular and flat-bottom notches, Proc. First U. S. nat. Congr. appl. Mech., 1951; J. W. Edwards, Ann Arbor, Mich., 309–315, 1952.

Experimental results reported in previous paper by authors [AMR **5,** Rev. 1527] indicate that, through the use of multiple semicircular notches, increased strength may be obtained along with reduction in weight. Analysis by photoelastic method is here reviewed and extended to include flat-bottom notches. Results of all tests are plotted, showing maximum factor of stress concentration as ordinate vs. length occupied by notches along edge of plate as abscissa. Graph shows family of curves becoming lower as number of notches increases, with that for flat-bottom notches appearing as limit.

Authors present interesting discussion of techniques for minimizing errors and checking boundary stresses. Creep properties of the CR-39 model material are studied by tests on tensile specimens showing that creep is proportional to stress, thus leaving the measurement of the factor of stress concentration unaffected by creep. Effect of finite plate width is studied by two distinct methods, with the conclusion that width used caused relatively small error. A brittle coating used on one model pro-

vided the locations of isostatics, which were used to estimate the principal stresses at the free boundary and across the plate.

C. Richards, USA

440. **Strel'bitskaya, A. I., Experimental investigation of the torsion of thin-walled beams beyond the elastic limit** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **13**, 47–64, 1952.

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 392, 408, 409, 410, 411, 428, 435, 462, 487)

441. **Goldberg, J. E., The application of Heaviside's step-function to beam problems,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 202, 13 pp., July 1953.

Method of title is illustrated by problems such as a simple beam with several loads and a beam with partial distributed or linearly varying load. In reviewer's opinion, there is not much new in the paper. Moreover, graphical methods such as Mohr's, or analytical such as Maxwell's or Castigliano's, seem to yield more rapid or conspicuous results. F. K. G. Odqvist, Sweden

442. **Kacner, A., Improvement of the calculation of continuous beams and frames. The "RWR" method** (in Polish), *Inżyn. Budown.* **10**, 1, 25–30, Jan. 1953.

Author describes the method called the "RWR" method, i.e., the method of true distribution coefficients as applied to calculation of continuous beams and frames. This method was described previously [title source **8**, 11, 434–442, Nov. 1951]. The significance of this method shows itself when, directly after the release of the joints, the final values of the moments are obtained without calculating the successive approximations. In this article the author demonstrates the simplifications which result from the symmetry of the system and solves two numerical examples. Continuation of this article will appear in subsequent numbers of the same periodical. J. Szymkiewicz, Poland

443. **Mansfield, E. H., The diffusion of load into a panel bounded by constant stress booms and a transverse beam,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2729, 12 pp., Aug. 1948, published 1953.

A long, flat, rectangular, length wise stiffened panel is connected at its long edges to booms and at its short edges to beams. Equal forces are applied to the boom ends. Analysis is given of the elastic deformation of this structure under static conditions. It is supposed that the booms are to be designed for constant stress, and the main objective is to determine the required boom taper and the beam stiffness for efficient diffusion of applied force. A simplifying assumption is that the stiffened panel may be replaced by a stringer sheet, and the support afforded to the beam ends by the booms is taken to correspond either to simple-support or built-in conditions. Numerical results are presented in the form of design charts. The most significant result, although not unexpected, is that the maximum shear stress in the panel is considerably reduced through taking the boom ends to be built-in rather than simply supported; but this apparent advantage is offset by the introduction of high bending moments at the beam ends which necessitate additional stiffening material.

H. G. Hopkins, USA

444. **Matildi, P., The influence of shear on the instability of axially compressed bars in an elastic medium** (in Italian), *Atti Ist. Sci. Costruz. Univ. Pisa Pubbl.* no. 23, 17 pp., 1952.

Author compares the different forms of energy methods for calculating critical loads of compressed bars with respect to their accuracy. By introducing the influence of the shear on the deformations of a compressed bar in an elastic medium, a generalized equation of the problem is found. Comparison with the corresponding formulas of S. Timoshenko without considering shear ("Theory of elastic stability," Art. 21) shows that the influence of shear increases the number of half waves while the critical load is decreasing. This influence increases considerably with increasing modulus of foundation. Tables are given for practical calculation of foundation piles. F. Stüssi, Switzerland

445. **Ōkubo, H., The torsion of spiral rods,** *J. appl. Mech* **20**, 2, 273–278, June 1953.

Elastic analysis of stresses in spiral rods. Equations of equilibrium are derived in two-dimensional form and are simplified for two extreme cases: (1) Small helix angle, (2) large helix angle. Expressions for stresses are derived in terms of two functions, one satisfying the Laplace or similar equations, and the other the Airy equation. An illustration analyzes a coiled helical spring of circular section by successive approximations.

From author's summary by G. Winter, USA

446. **Esser, K., Calculation of compression springs of circular wire section** (in German), *Maschinenbau-Technik* **2**, 5, 192–197, May 1953.

To obtain optimum resilience at minimum weight and minimum space, the maximum shear stress should be taken as high as possible. Allowable shear stresses in wires of various diameters and a number of representative spring materials are given for both static and dynamic loading conditions.

J. A. Haringx, Holland

447. **Botka, I., The interference of normal involute toothings** (in German), *Maschinenbau-Technik* **2**, 3, 108–115, Mar. 1953.

See AMR **6**, Rev. 1488.

Plates, Disks, Shells, Membranes

(See also Revs. 385, 413, 414, 433, 435, 439, 459, 460, 461, 502)

448. **Craggs, J. W., The shearing of a rectangular block between rough plates,** *J. appl. Mech.* **20**, 2, 270–272, June 1953.

Author presents an analytical solution to the problem of determining the stresses in a rectangular block having a pair of opposite faces mutually displaced in the direction of an edge. Problem differs from one of uniform shear in that the shear stresses vanish on the free faces of the block.

Numerical results presented are correct only for plane strain. Further investigation by author indicates, however, that the effect of introducing a finite block is small.

R. E. Heninger, USA

449. **Norris, C. B., and Kommers, W. J., Stresses within a rectangular, flat sandwich panel subjected to a uniformly distributed normal load and edgewise, direct, and shear loads,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1838, 11 pp., 1 table, 5 figs., Jan. 1953.

Theoretical and experimental investigations are made to find the deflections, bending moments, shear loads, and reactions of rectangular sandwich panels subjected to a uniformly distributed normal load, two edgewise compressive loads, and an edgewise shear load. Without the shear load, experimental data agree reasonably well with the theoretical results when the deflections

are small compared with the thickness of the panel. The effect of the edgewise shear load was so small in the tests that its comparison with theory was not possible. C. T. Wang, USA

450. Nowacki, W., Rectangular plates with mixed edge conditions (in Polish), *Arch. Mech. stos.* **3,** 3–4, 419–433, 1951.

In this paper author solves two types of problems: (1) Plate freely supported on two opposite edges, completely clamped on a certain segment and freely supported on the rest; (2) rectangular plate additionally supported on linear segments parallel to the edges. Solution consists of two parts, one of them, $w_0(x,y)$, being the solution for the plate of uniform edge conditions; the second, $w_1(x,y)$, taking into account the influence of clamping or supporting on the segments. The solution is obtained in the form of Fredholm's integral equation of the first kind or in the form of a set of integral equations. The proposed procedure is illustrated by the example of a plate in the form of a half strip with mixed edge conditions on the short side (full clamping on the segment c_1, free support on the rest of this side). The solution leads to the equation

$$[\partial w_0(x,0)/\partial y] + c_1 \int M(\xi)[\partial K(x,0;\ \xi,0)/\partial y]d\xi = 0$$

where $M(\xi)$ is the unknown function of clamping moments on the segment c_1, and $K(x,y;\ \xi,0)$ is Green's function for the freely supported half strip for the state $M = 1$, acting in $(\xi,0)$ of the short side of the plate. W. Olszak, Poland

451. Boston, D. C., Deformations and stresses in symmetrically loaded circular plates of varying thickness, *J. roy. aero. Soc.* **57,** 511, 449–454, July 1953.

Method described treats the plate as a series of concentric uniform thickness annuli. Starting from the usual equations for deflection, radial bending moment M_r, and tangential bending moment M_t (equations according to the simple theory of plates and shells), author expresses the slope in radial direction in M_r and M_t. He introduces a sum and difference notation, $S = M_t + M_r$, $D = M_t - M_r$, and gets the change in S and D ($\delta S = \delta D$) at a junction of adjacent sections by equating boundary conditions at the junction. Solution for the complete plate is then obtained in terms of boundary conditions at inner and outer edges.

Equations for S and D are derived for three different systems of loading, namely, concentrated circumferential load, uniformly distributed pressure load, and couples applied at edges. Each equation contains an arbitrary constant and, by assigning to it various values, a family of curves can be drawn for each equation. When using such charts for plates of varying thickness, two trial sets of S and D curves must be drawn. From these curves the correct initial values of S and D can be obtained, enabling the third and final solution to be obtained. Initial values of S and D for the two trials can be chosen arbitrarily but must satisfy boundary condition at inner edge of plate; for example, $M_r = 0$ at a free edge gives $S = D$. S and D known at any section stresses are easily computed. Deflection can be found graphically.

By assuming temperature to be constant over a section and equal to mean temperature of the section, author takes account of a temperature gradient by varying Young's modulus according to temperature in the expression for $\delta S(= \delta D)$.

As linear differential equations are used, method outlined is valid only for small ratios of deflection/plate thickness and plate thickness/outside diameter. E. Steneroth, Sweden

452. Vaĭnberg, D. V., Analogy between problems for plane stress and bending of a circular plate of varying thickness under asymmetrical load (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 749–752, Nov.-Dec. 1952.

453. Fung, F. C., Bending of thin elastic plates of variable thickness, *J. aero. Sci.* **20,** 7, 455–468, July 1953.

In terms of the plate deflection, the boundary conditions for the thin plate involve second- and third-order derivatives which are difficult to use. Author avoids some of this difficulty by using two "stress functions" of such form that the boundary conditions can be expressed in terms of the two functions and their first derivatives. Theory is applied to a square plate with linear thickness variation (double-wedge section) simply supported at two diagonal corners and loaded by concentrated forces at the other two corners. Southwell's relaxation procedure is used to obtain the stresses and deflections. Limited experimental results for stresses in this plate agree satisfactorily with the theoretical results. The procedure is also applied to obtain stresses in a 45° swept wing with constant thickness over forward 50% chord and linear thickness variation over aft 50% chord. B. E. Gatewood, USA

454. Kirste, L., Elastic deformation of a thin plate into a developable surface generated by motion of a straight line (in German), *Öst. Ing.-Arch.* **7,** 2, 134–139, 1953.

Author considers a rectangular plate subjected to twisting moments along two stiffened parallel edges, the remaining two edges being free. Discarding the assumption of small angle of rotation, author shows how longitudinal stresses appreciably increase the rigidity of the plate. He also shows that, if buckling occurs, this rigidity again approaches a constant value. Comparison with experiment is made and reasons for deviation of experiment and theory are presented. M. Stippes, USA

455. Zaid, M., Fully plastic rotating disc with large strains, *J. aero. Sci.* **20,** 6, 369–377, June 1953.

A large strain theory of rotating disks for materials with an arbitrary stress-strain curve is presented. This solution is based on the deformation theory using the large strain expression according to Ludwik, and may be obtained by a numerical process in the strain plane for a wide variety of edge conditions and profile shapes. The bursting speed of the disk is found to depend largely on its profile shape. Furthermore, the bursting speed predicted by this large strain theory is considerably higher than that indicated by previous small strain theory. The result based on the large strain theory is found to be in good agreement with experiments on flat steel disk in both the disk speed for unrestrained flow and the strain distributions. C. C. Wan, USA

456. Czulak, J., Simplified calculation of the ribs of shell (in Polish), *Inżyn. Budown.* **9,** 10, 329–333, Oct. 1952.

Author discusses the problem of the spherical shell uniformly loaded and supported by meridional ribs possessing angular symmetry. Those ribs are jointed on the apex by a rigid joint and are hinged at the lower end. Since the loads and structure are symmetrical, each rib works under the same conditions. Thus, the problem reduces to the plane problem, i.e., to calculation of the half circular arch, fixed at one end and free at the other, loaded by continuous triangular load. Author solves the problem introducing his own method, previously disclosed in his work [see AMR **4,** Rev. 4138]. J. Szymkiewicz, Poland

457. Kolesnikov, K. S., Determining the displacement in a closed, torus-shaped shell with inner stresses (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12,** 234–238, 1952.

458. Nowacki, W., Orthotropic plate strip (in Polish), *Arch. Mech. stos.* **3,** 3/4, 259–270, 1951.

Paper analyzes the freely supported orthotropic plate strip acted on by a concentrated load. The solution of the quasi-bi-

harmonic differential equation for the deflection of the plate is found by means of the solution of a set of two partial eqations; this constitutes an analogy to the two-step method given by H. Marcus for isotropic plates. Author obtains the expressions for bending moments, twisting moments, and shearing forces in finite form for all kinds of orthotropy ($\rho \gtrless 1$). The results may be used for the computation and construction of influence surfaces for the considered plate strip. W. Olszak, Poland

Buckling Problems

(See also Rev. 454)

459. **Anderson, R. A., and Semonian, J. W., Charts relating the compressive buckling stress of longitudinally supported plates to the effective deflectional and rotational stiffness of the supports,** *NACA TN* 2987, 53 pp., Aug. 1953.

This very interesting analysis is an attack on a very complicated problem. The analysis based upon several reasonable simplifying assumptions provided a way of predicting the buckling load of stiffened sheet construction. Further research is needed in two categories; one the simplification of the procedures, and the other the substantiation of the predictions by test data. The analysis will provide an excellent framework for coordinating experimental results.

The charts as plotted provide a means for calculating a wide range of parameters for the six types of stiffened plate construction considered. R. G. Sturm, USA

460. **Stüssi, F., Kollbrunner, C. F., and Wanzenried, H., Buckling of rectangular plates under compression, bending, and compression combined with bending** (in German), *Mitt. Inst. Baustat. ETH, Zürich* no. 26, 35 pp., 1953.

The problem of buckling of flat rectangular plates, longitudinally stressed on opposite sides by constant or linearly varying forces, is solved by an iteration method replacing the differential equation of the problem by a set of linear difference equations. Detailed computation is given for two examples. Tables and diagrams give a complete survey of the numerical results for the critical load for various boundary conditions on the remaining two edges (simply supported, free, built in, and all mixed cases), dependent on the side ratio and the stress distribution. Results are compared with earlier notes on special cases and give differences to the amount of 8% of the critical load.

H. Kauderer, Germany

461. **Wittrick, W. H., Buckling of oblique plates with clamped edges under uniform compression,** *Aero. Quart.* **4,** part II, 151–163, Feb. 1953.

Author analyzes the title problem, of interest to swept-wing aircraft design, by means of the Rayleigh-Ritz method referred to an oblique coordinate system. The expressions for the deformed middle surface of the plate are linear combinations of functions previously used by S. Iguchi for rectangular plates. Any stress system uniformly distributed along each of the sides of the plate is covered by the general theory, which gives an upper bound for the critical loads. Specific numerical results are given for uniform compression in the direction of one side of the plate, sweepback angle of 30 and 45°, and ratios of the two sides between 3/5 and 5/3. For a rhomboidal plate, a comparison with previous results of Guest, who obtained a lower bound by the method of Lagrangian multipliers, shows that the accuracy of the numerical values is at least within 5% of the exact value, or within 2.5% if the mean of the values found by the two methods is used.

G. A. Zizicas, USA

462. **Davidson, J. F., Flange buckling in a bent I-section beam,** *J. Mech. Phys. Solids* **1,** 3, 149–163, Apr. 1953.

Author extends his previous work [AMR **6,** Rev. 429] to the problem of flange buckling in an I-section beam bent by pure couples inclined at angles between 0 and 90° to the web. In the theoretical analysis, the buckled flange has been treated as a flat and infinitely long elastic plate, compressed by thrusts in its own plane and parallel to two opposite edges. One of these edges is free, the other being fixed in position but elastically clamped. The thrusts in the plane of the plate vary linearly across its width. Two approximate methods—Rayleigh-Ritz and Schwarz methods—were used to calculate the critical load. In his calculations, author estimates amount of elastic clamping by using the data of Kroll ["Table of stiffness and carry-over factor for flat rectangular plates under compression," *NACA ARR* 3K27]. The theoretical results have been checked favorably by experiment.

T. H. H. Pian, USA

463. **Wasiutyński, Z., On the shapes of equal strength in bent and compressed columns** (in Polish), *Arch. Mech. stos.* **3,** 3/4, 347–370, 1951.

Rules are developed and discussed, leading to a rational design of eccentrically compressed columns of equal strength. The shape of constant strength of a section in a bent and compressed column depends solely on the shape of the locus of all possible normal load resultants. If the enveloping line of all these positions is given, it is possible to obtain the most economic shape of a column section which would be loaded to the given admissible stress in at least one of its contour points; under such loading conditions, its normal resultant components would be located on the said envelope. Several numerical examples illustrate the theory and show the difficulty of obtaining practically useful optimum section shapes in certain cases. Author recommends the design of larger sections but of more practical forms, giving numerical examples of such designing methods.

J. Naleszkiewicz, Poland

464. **Masur, E. F., The effect of prestressing on the buckling loads of statically redundant, rigid-jointed trusses,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 443–448, 1952.

The equations governing the extremum values of the buckling loads are derived and applied to the case of a simply redundant truss. It is shown that the critical loads can be increased through the introduction of suitable initial stresses.

S. E. Kindem, Norway

Joints and Joining Methods

(See also Rev. 501)

465. **Cornell, R. W., Determination of stresses in cemented lap joints,** *J. appl. Mech.* **20,** 3, 355–364, Sept. 1953.

Paper presents solution of the cemented lap-joint problem using a method similar to that given by Reissner and Goland for such cases by assuming that the two lap-joint plates act like simple beams and the more elastic cement layer can be represented by an infinite number of shear and tension springs. Differential equations may then be set up which describe the transfer of load from one beam to the other. The solution of these equations affords an approximate description of the load transfer and the stresses set up in the cement layer. The analytical solution given is compared with a considerable amount of experimental work done by photoelastic and brittle lacquer methods. A comparison of results shows fairly good agreement except at the discontinuity at the end of the lap joint.

The experimental data given would be of considerable interest in design work involving jointing methods employing cement or brazing. W. J. Carter, USA

466. Diehl, C., Blumberg, H. S., and Benz, W. G., Jr., Controlled internal-contour shielded-root welds without backing rings, *Trans. ASME* **75,** 6, 1103–1110, Aug. 1953.

Inert-gas arc welding of pipe and other weld-root beads supplemented by inert-gas inside shielding has improved greatly the deposited-metal quality and degree of penetration, but requires superlative operator skill to achieve reasonably uniform results. The process which is the subject of this paper, through precise control of technique, physical dimension, and internal-shielding gas pressure, provides assurance of complete penetration, uniform root-bead inside surface free of undercutting, and desired degree of root-bead reinforcement, with only average operator proficiency. This process of controlled contour-shielded root welding, designated as "K-Weld," has been applied successfully to $9^1/_2$-in. OD $\times$ $1^5/_8$-in. wall Type 347 austenitic utility main steam lines and other difficult applications. From authors' summary

467. Voldrich, C. B., On the welding of titanium alloys, *Weld. J.* **32,** 6, 497–515, June 1953.

A presentation of test data giving the effects of welding on titanium and its alloys, as measured by tensile strength and ductility. Titanium must be welded in an inert-gas atmosphere to prevent embrittlement of the weld and base metal. For ductile welds, limiting amounts of carbon (0.20%), nitrogen (0.10%), and oxygen (0.10%) alloys are given. With pure titanium and titanium-aluminum alloys, ductile weld joints are possible. With manganese and low-chromium alloys, weld ductility is poor and does not respond well to heat treatment. High-chromium alloys, 15%, give welds of good ductility. I. A. Benjamin, USA

468. Baimler, M., Testing of pipe welds by x-rays and gamma-rays, *Engng. Rev., Prague* no. 8, 1–17, Apr. 1951.

Paper describes techniques for radiographic examination of pipe welds using x rays and gamma rays. Author concludes that, in order to obtain optimum sensitivity to defects, it is necessary (a) to provide the proper geometrical relationship between radiation source, subject, and film; (b) to employ high-contrast, fine-grain x-ray film; and (c) to follow closely the directions for film developing supplied by the film manufacturer. The preferred radiographic technique consists of placing the radiation source internally at the pipe axis and wrapping the film circumferentially around the pipe at the weld. Where the pipe is too small to permit insertion of an x-ray tube, rather than locate both the x-ray source and the film externally on opposite sides of the pipe, use of a gamma-ray source placed internally is preferred (in this paper, radon or mesothorium is recommended; however, in the USA, cobalt 60 or other radioisotopes are frequently employed). The two-wall technique (radiation source and film both located externally) should be employed only when internal placing of the source or film is impractical.

From author's summary by F. J. Winsor, USA

469. Akao, S., and Yasumi, M., On the torque wrench, *Technol. Rep. Osaka Univ.* **2,** 183–200, Oct. 1952.

This research was undertaken as a preliminary study on tightening clips for the cables of suspension bridges.

The efficiency of clip joints of cables depends on the frictional resistance produced by the clamping force of clip bolts. Therefore, to guarantee a fixed efficiency, it is necessary that the torque applied to bolts should be measured by a torque wrench and, at the same time, the relation between bolt tension and applied torque should be established. Two types of torque wrenches with dial indicators to record the tightening torque were made for trial. To establish the torque-clamping force relation, electric resistance-wire strain gages were used to measure bolt tension.

The relation between the bolt tension P and the applied torque T was found to be given by the formula $T = C \cdot D \cdot P$, where D is the nominal diameter of the bolt and C is a constant equal to 0.19. From authors' summary

Structures

(See also Revs. 405, 406, 442, 443, 464, 635, 638)

470. Dunham, C. W., The theory and practice of reinforced concrete, 3rd ed., New York, McGraw-Hill Book Co., Inc., 1953, xiii + 499 pp. $7.

This third edition represents an enlarged treatment of the more elementary parts of reinforced concrete, "leaving indeterminate structures and advanced material for the graduate student and practicing engineer" to a proposed subsequent volume. Nevertheless, the entire text emphasizes the viewpoint of the practicing engineer as well as the teacher, and many valuable practical design considerations and details are discussed.

The first 63 pages are on properties and manufacture of concrete. Other subjects not always included in elementary texts are: Composite beams, retaining walls, forms, precast concrete, prestressed concrete, architectural and miscellaneous details.

The transformed area idea is introduced only as a moment-of-inertia or section-modulus concept, not for the concept of the fundamental internal couple. The subject of bond is more adequately treated than in most texts. Bond and shear are explained with frequent reference to recent research, a most commendable feature. This is first text the reviewer has seen which points out the increased stress in tension steel arising from formation of diagonal tension cracks, as distinct from moment cracks. Ultimate strength relations for both beams and columns, including eccentricaily loaded columns, are included in some detail. Retaining-wall design is well organized and covers 40 pages.

This text is written for students who have not had prior training in the field of continuity. It does not attempt to teach continuity as such, but the author does introduce the idea of negative moment steel and an occasional moment diagram which applies to a continuous beam. The loadings for maximum moment are not discussed, and designs are chiefly for statically determined elements with a given moment diagram. The bending of bars in continuous beams is even discussed, but briefly. Two-way and flat slabs are included, even though these are highly indeterminate. Reviewer misses material from earlier editions on the distribution of concentrated loads on one-way slabs and detailed information on the bending moments in slabs.

Reinforced concrete is rarely statically determinate. Hence a text or a course which must skirt around the subject of continuity is necessarily under a handicap, in the opinion of reviewer. The author has handled this handicap rather skillfully.

P. M. Ferguson, USA

471. Wright, W., The design of reinforced concrete beams of large initial curvature, *Mag. Concr. Res.* no. 12, 117–120, Apr. 1953.

For R/d ratios of 8 or less, the design of a curved beam differs appreciably from that of a straight beam. Author obtains the equations for balanced design, for bending moments that increase, and those that decrease the initial curvature. Design charts are given for the case of pure bending (no longitudinal force) for a

certain set of permissible stresses and ratio of moduli. Author concludes that, when loading tends to decrease the initial curvature, the balanced section is shallower and more heavily reinforced than would be a straight beam under the same moment. For opposite bending the reverse is true. Paper is concise and clear. M. P. White, USA

472. **Crom, J. M., Design of prestressed tanks,** *Trans. Amer. Soc. civ. Engrs.* **117,** 89–107, 1952.

Description of and justification for a method of constructing prestressed reinforced-concrete storage tanks by winding high-tensile steel wire under tension around the tank. Author shows that more common prestressing methods using ordinary steel reinforcing rods may become ineffective due to the compressive creep or plastic flow of the concrete. Creep tests at MIT with concrete and gunite are quoted in which blocks were prestressed by ordinary steel tension rods. While conjectures are drawn as to the probable behavior of similar test specimen prestressed with high-tensile wire, the paper suffers from the absence of tests confirming the author's conjectures.

The need for vertical reinforcing is emphasized to prevent horizontal cracking from bending stresses in a vertical plane, and here also the author recommends the use of high-tensile steel wire.

A detailed description of the methods used by the author's company of the construction of such tanks concludes the paper. E. G. Chilton, USA

473. **Olszak, W., Effect of mechanical material properties on the theory of prestressed structures** (in Polish), First Concr. Conf., Warszawa, 154–159, 1952.

What distinguishes the theory of prestressed structures from that of "classical" structures is the necessity of taking into account delayed plastic deformations of both concrete and steel. Author analyzes the rheological properties of materials, discusses the mechanism of creep and shrinkage of concrete, and shows how they affect the state of stress of prestressed structures. In steel, beside its elastic strain, the phenomenon of relaxation occurs. Analysis of losses in prestress, involved by elastic and plastic deformations as well as shrinkage, is presented. Author applies theoretical results to different technological processes of manufacture; e.g., anchorage by bond is necessarily accompanied by losses caused by elastic deformations and full shrinkage; mechanical anchorages avoid elastic losses and part of shrinkage. Comparative formulas and figures are given. St. Kaufman, Poland

474. **Chaplígin, D. V., Building massive hydrotechnical structures from vacuum processed concrete with a lower cement content** (in Russian), *Gidrotekh. Stroit.* no. 1, p. 37, Jan. 1953.

475. **Shvetsov, A. V., Method of calculating reinforced-concrete construction of hydrotechnical structures, taking the time element into account** (in Russian), *Gidrotekh. Stroit,* no. 12, 26–30, Dec. 1952.

476. **Przestepski, W., Obtaining the required strength of walls while building in winter** (in Polish), *Inżyn. Budown.* **8,** 10, 380–383, Oct. 1951.

In this work the author maintains that, in the climatic conditions of Poland, the only method which should be used is that of "retaining heat." Using known formulas of the strength of the brick walls and cooling of the physical bodies, author worked out a whole series of charts and tables which enable the configuration of certain facts and the carrying out of the calculations by technicians of average qualification. On this basis, author calculated and worked out a number of graphs which, without troublesome figuring, allow (1) the choice of suitable mortar, (2) establishment of the temperature of the finished brick wall, (3) establishment of the loss of heat depending on the type of protection used, (4) establishing the time during which the brick wall is in the temperature above 0 C, (5) establishment of the strength of the mortar in relation to the period of its remaining in the temperature above 0 C. In the table for choosing mortar, 20 types are given, differing according to the added amount of $CaCl_2$ or cement. Special attention is given to the heating properties of the mortar.

For every type, there is given the amount of calories of exothermic heat given out for every m^3 during the first 24 hours after completion. From the next table, [assuming] that the bricks on the building site have the temperature of the surrounding air and counting the temperature of the mortar in freshly erected brick wall, we can fix the temperature which this brick wall should have immediately after the work is finished. The following chart enables the determination of the time of the cooling of the brick wall to 0 C. This depends on the starting temperature, the exterior temperature, and the type of protection. These charts are worked out for different mortars and various percentages of $CaCl_2$ addition. The last table enables the establishment of the strength of mortar. Therefore, by availing oneself of these tables and using only measurements of temperature, it is possible to determine the strength of the brick wall. This allows taking remedial measures (heating) in cases where insufficient strength is obtained. In the Polish climate this eventuality may occur very rarely (5–10% cases). W. Zeneczykowski, Poland

THE FOLLOWING PAPERS (Revs. 477–480) WERE PUBLISHED IN *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.,* Aug. 16–27, 1953, in 3 vols. 75 SFr per set.

477. **Caille, J., and Barbedette, R., Preliminary grouting method for difficult cases of tunnel driving** (in French), vol. II, 157–161.

478. **Mayer, A., In-situ tests on rocky soils and prestressing of tunnel linings** (in French), vol. II, 185–187.

Author sums up the research work carried out at the Laboratoire du Bâtiment et des Travaux Publics in Paris, and work done on rock in situ in recent years.

Two methods for measuring the modulus of elasticity of rocks in situ have been devised, one using jacks, by Habib and Delarue, the other using an acoustic measuring device, by L'Hermite and Chefdeville. Both methods have been applied in the field, on Electricité de France projects, and in Morocco.

A method for measuring stresses around a cavity in rock by means of a Freyssinet-type flat jack has been worked out and applied by Tincelin in the iron ore mines of France for determining the stresses and elastic coefficients within the rock.

Finally, a method of computing the thickness of the lining of a pressure channel in rock has been worked out by Delarue.

At the end of this report the author indicates how such a lining can be precompressed by grouting with expensive mortar, thus permitting an important reduction of the thickness of the lining and the amount of steel. From author's summary

479. **Peterson, R., and Iverson, N. L., Study of several low earth dam failures,** vol. II, 273–276.

This paper describes typical failures of low earth dams that were constructed on intermittent streams using dry glacial clay.

The failures were due to piping through the fill during the first filling of the reservoir. It is believed that this was a result of volume reduction of the less dense portions of the embankment when subjected to saturation from the rapidly filling reservoir. The paper discusses the possibility of establishing the minimum allowable water content and dry density of a proposed dam so as to result in a stable structure at the least possible cost. Methods of obtaining the necessary water in a semi-arid region are described. Alternative methods of insuring a stable dam by controlling the saturation of dry embankments in place are discussed briefly. From authors' summary

480. Walker, F. C., The design of earth dams for pervious foundations, vol. II, 294–298.

Operation of earth dams on pervious foundations has disclosed the need for consideration of factors commonly overlooked in the design of earth dams. Analysis of the geological situations has disclosed several recurring groups of conditions that can be treated satisfactorily if they can be identified in advance of construction.

Performance records based on measurements of pressures in internal pore fluid have resulted in the development of hypotheses that explain structural behavior under specific circumstances. These hypotheses have also been used to explain performances in older structures previously imperfectly understood.

From author's summary

481. Harrison, E. S., and Kindsvater, C. E., Dam modifications checked by hydraulic models, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 184, 17 pp., Apr. 1953.

Author describes model studies of Bartlett's ferry dam for original and modified designs. Model studies indicated improved flow conditions due to additions of buttresses required for strengthening of dam. Prototype observations agree well with model studies. Authors also describe details of dam modifications and analysis which pointed to the need for modifications.

W. M. Owen, USA

482. Zanger, C. N., Hydrodynamic pressures on dams due to horizontal earthquakes, *Proc. Soc. exp. Stress Anal.* **10,** 2, 93–102, 1952.

An electrical analogy has been used to determine experimentally the hydraulic pressures due to the action of horizontal earthquakes on dams having upstream faces with either constant or compound slopes. Use of the analogy requires the assumption that water is incompressible, and this has been justified by comparison of results with a previously published exact analytical solution for dams with vertical faces.

Analytical approximations to the results have been derived for the special case of dams with constant slopes which enable expressions for the total horizontal force and overturning moment above any elevation to be formulated. A brief discussion of the earthquake intensities that may be applied to dams is also given.

In places the treatment is sketchy, especially in the discussion of the electrical counterparts of the fluid displacement lines and lines of equal pressure; also, the electrical conditions at the boundaries and free surface to comply with the analogy are not clearly brought out. G. H. Lean, England

483. Lisowski, A., Calculation of space frames by the method of equilibrium of joints (in Polish), *Inżyn. Budown.* **10,** 1, 20–24, Jan. 1953.

Author discusses the method of calculation of space frames based on the equations of equilibrium of the joints. Following the derivation of the basic relationships between the angles of rotation and the bending and twisting moments, author derives the equations of equilibrium of links and joints separately cut out from the frame. He obtains the system of linear equations with symmetrical matrix. Next, author obtains the angles of rotation of joints and the components of the displacements of joints and calculates the fixing moments. The above equations are of complicated nature. Author solves them by introducing certain simplifications, shown by numerical examples taken from commonly built structures. J. Szymkiewicz, Poland

484. Bosovskiĭ, L. M., and Zagryazhskiĭ, A. A., Drainage of dams built from hollow concrete blocks (in Russian), *Gidrotekh. Stroit.* no. 12, 21–23, Dec. 1952.

485. Takabeya, R., On economical number of stories for multiple-storied rigid frames, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2,** 5, 1–14, Mar. 1953.

Theoretical investigation in which beams are assumed square or rectangular in cross section considers merely the effect of bending moments. It is limited to single-bay bents with uniform story height and loaded with one concentrated horizontal force at top of the frame. G. P. Fisher, USA

486. Lesniak, Z., Computation and design of thin slab vaults curved in two directions (in Polish), *Inżyn. Budown.* **9,** 11, 364–367, Nov. 1952.

During his visit to the laboratory of Profs. Hacar, Waitzmann, and Kounovsky in Prague, the author became acquainted with a method of calculation of internal forces in a uniformly loaded thin-slab conoidal vault. The present paper describes that method. The starting point is the differential equations of equilibrium for a membrane-type stress distribution. Establishing the relation between the coordinates of a point on the mean surface of the vault and introducing it in the differential equations of equilibrium, author obtains a partial-differential equation with one unknown function. The solution of this equation is based on that of the corresponding simplified differential equation. Assuming the corresponding normal stresses to be equal to zero at points of junction of the vault with the longitudinal beams and the arches, the final form of the formulas for internal forces is obtained. Finally, a numerical example is given to illustrate the way of determining the internal forces in a conoidal vault.

J. Czulak, Poland

487. Amirikian, A., Wedge-beam framing, *Trans. Amer. Soc. civ. Engrs.* **117,** 596–631, 1952.

Wedge-beam framing, suggested by author as a substitute for continuous framing with members of constant section, consists of tapered members rigidly connected at their butt ends and essentially hinged at small ends. Hinges are generally placed at midspans of beams and at bases of columns. Moment diagram for each tapered element becomes cantilever type, and tapered shapes lead to more economical placement of bending material. Hinges also simplify analysis, since degree of indeterminacy, as compared to continuous framing, is reduced. Sketches suggest use of system for butterfly and saw-tooth roofs comprising both straight and curved members, and for multiple-story construction.

Author presents deflection formulas for tapered members, illustrative examples of analysis based upon standard methods, and tabular procedure for organizing work. Reviewer notes that tapered, haunched, or curved girders and columns, such as are generally seen in rigid-frame bridges, tend to achieve the same economical result without complication of hinges and may,

in some cases, have a more favorable bending moment diagram, but at expense of somewhat more analytical effort on the part of the designer. J. E. Goldberg, USA

483. **Ivy, R. J., Lin, T. V., Mitchell, S., Raab, N. C., Richey, V. J., and Scheffey, C. F., Live loading for long-span highway bridges,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 198, 13 pp., June 1953.

Based on a traffic survey on the San Francisco-Oakland Bay Bridge, Calif., a live-loading curve is suggested for the estimation of the bending and shearing stresses of bridges with spans exceeding 400 feet. Reviewer considers that survey on single bridge is insufficient to propose general recommendations, especially since no account has been taken of loading specified in other countries for long-span bridges. G. G. Meyerhof, Canada

489. **Szelagowski, Fr., Rational forms of bridge arches** (in Polish), *Arch. Mech. stos.* **3,** 3/4, 271–291, 1951.

Paper deals with the rational forms of bridge arches under action of ballast and earth filling. It is assumed that the arch is flat. The terms containing the second derivative of the arch ordinates and the horizontal components of the earth-filling pressure are neglected. The problem is considered as a variational one. It consists of determining the equation $y = f(x)$ of the arch axis according to the condition of minimum of the integral $W = \int_{-l}^{+l} (M^2/2EJ_0)dx$, giving the potential energy of elastic deformation due to the bending moments of the arch. The equation $y = f(x)$ may also satisfy the conditions of equilibrium and the conditions at edges.

To simplify this problem, author calls attention to the fact that the values of bending moments are the greatest at skewbacks and gives solutions in which these values depend upon several coefficients of a differential equation. The arch axis for different values of these coefficients arrives at same forms which are found by Denfert-Rochereau, Legay, Tolkmitt, and Hagen.
Z. Wasiutyński, Poland

490. **Howe, D., Strain energy analysis of swept boxes with ribs normal to the spars,** *Coll. Aero. Cranfield Rep.* no. 63, 49 pp., May 1953.

The root constraint problem associated with uniform rectangular swept boxes, having ribs normal to the spars, is considered. A strain-energy method using self-equilibrating internal end-load systems is used.

Solutions are presented for the cases of a single cell box having either all ribs rigid or the root rib flexible. In addition, consideration is taken of second-order effects combined with a flexible root rib. The case of a box having two equal cells, with all ribs rigid and a built-in root, is investigated and the method of dealing with special root connections in this case is indicated. The effect of the flexibility of the root rib in the two-cell box is also considered.

In all cases, the boxes are analyzed for loading by a torsion couple and a normal force applied on the centerline at the tip.
From author's summary by G. Isakson, USA

491. **Langrod, A., Theory of flanges of the wheels of railway vehicles** (in Polish), *Arch. Mech. stos.* **3,** 3–4, 461–482, 1951.

Author characterizes two different groups of wheels of railway vehicles with regard to the profile of their flanges. In case of a lateral pressure on the rail, the wheels with flanges of the first group climb on the rail and are supported only at one point of contact of the flange with the rail. In similar circumstances, the wheels with flanges of the second group have two points of support on the rail, one of them lying on the flange of the wheel, the other on its tread (rolling surface). At the varying positions of the wheel relative to the rail, the condition can arise that the wheel may be derailed. The author explains these conditions from the geometrical point of view in relation to both types of flange profile. He notes that, from the point of view of statics, the question is not yet sufficiently examined. The fundamental difference in the behavior of the two types of flanges results in different conditions of wearing, both of flanges and rails. This question can be explained by experiments on the basis of the theory presented.
S. Skawinski, Poland

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 437, 455, 503, 506)

492. **Fourth Symposium on Plasticity,** Brown University, Providence, R. I., Sept. 1–3, 1953.

Proceedings of the Symposium will not be published, but authors' abstracts are available in booklet form from the Graduate Division of Applied Mathematics, Brown University, $0.30 ea. Papers presented at the Symposium are as follows:

Wave propagation in viscoelastic media, T. L. Alfrey, Dow Chemical Co., Midland, Mich., USA.

Dynamic viscoelastic behavior of linear high polymers, E. R. Fitzgerald, Pennsylvania State College, State College, Pa., USA.

A nonlinear analysis of static characteristics in viscoelastic materials, J. K. Knowles, Massachusetts Institute of Technology, Cambridge, Mass., USA.

Internal friction of single metal crystals in the audible frequency range, H. S. Sack, Cornell University, Ithaca, N. Y., USA.

Propagation of transient waves in viscoelastic materials, E. H. Lee, Brown University, Providence, R. I., USA.

Creep of concrete under sustained loads, D. McHenry, Portland Cement Assn., Chicago, Ill., USA.

Creep bending and buckling of linear and nonlinear viscoelastic columns, J. Kempner, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., USA.

Behavior of eccentrically loaded aluminum-alloy columns in the plastic stress range, J. W. Clark, Research Laboratories, Aluminum Co. of America, New Kensington, Pa., USA.

The collapse strength of a welded single-bay frame, F. W. Schutz, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa., USA.

Plastic deformations of beams and frames under blast loading, P. S. Symonds, Brown University, Providence, R. I., USA.

Experimental investigations in the field of plasticity, H. Ford, Imperial College of Science and Technology, London, England.

Effect of radially nonuniform metal properties on plastic deformation of a rotating disk, M. H. Lee Wu, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., USA.

Width effect in notched wide plates, W. P. Roop, Sewell, N. J., USA.

An analysis of the orthogonal boring operation, B. W. Shaffer, New York University, New York, N. Y., USA.

Plastic flow in the cutting and grinding of materials, M. C. Shaw, Massachusetts Institute of Technology, Cambridge, Mass., USA.

On the stress-strain relations and the general theorems of plasticity, W. T. Koiter, Laboratorium voor Toegepaste Mechanica, Technische Hogeschool, Delft, Holland.

On bending of beams in plasticity, A. Phillips, Stanford University, Palo Alto, Calif., USA.

The load-carrying capacity of circular plates, H. G. Hopkins and W. Prager, Brown University, Providence, R. I., USA.

The effect of strain-hardening on an annular slab, P. G. Hodge, Jr., University of California, Los Angeles, Calif., USA.

Formulation of stress-strain relations for isotropic materials, R. S. Rivlin and J. L. Ericksen, Naval Research Laboratory, Washington, D. C., USA.

On the concept of stability of inelastic systems, D. C. Drucker and E. T. Onat, Brown University, Providence, R. I., USA.

Finite deformation of axially symmetrical bodies under radial pressure, L. W. Hu and J. Marin, Pennsylvania State College, State College, Pa., USA.

A modified plastic flow law, G. H. Handelman and W. H. Warner, Carnegie Institute of Technology, Pittsburgh, Pa., USA.

Extension and application of the variational principles of plasticity, B. Budiansky, Structures Research Division, National Advisory Committee for Aeronautics, Langley Air Force Base, Va., USA.

Stress waves in imperfectly elastic solids, H. Kolsky, Imperial Chemical Industries, Ltd., Herts, England.

Thermal stresses in inelastic media, A. M. Freudenthal, Columbia University, New York, N. Y., USA.

On the initiation of plastic yielding, T. W. George and G. Irwin, Naval Research Laboratory, Washington, D. C., USA.

Analytical expressions for propagation of plastic waves in rod, E. A. Davis, Research Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa., USA.

Plastic behavior of polycrystalline metals at very high strain rates ($\sim 10^4$/sec), L. Zernow, Terminal Ballistic Laboratory, Aberdeen Proving Ground, Md., USA.

493. Nowick, A. S., Internal friction in metals, *Progress in Metal Physics* **4,** 1–70, 1953; New York, Interscience Publishers, Inc.

Comprehensive review of present knowledge of internal friction at low stress levels, with primary emphasis on the use of the phenomena to study internal structure and atomic movements in solids. Damping capacity at higher stresses of engineering design interest is not treated. A general description of nonelastic deformations is given which includes anelastic amplitude-independent phenomena as well as amplitude-dependent internal friction and static hysteresis. Under the concept of a generalized Maxwell solid, involving an elastic strain plus a nonelastic strain of various forms, the standard linear solid, the viscoelastic solid, and static hysteresis are discussed. Mechanisms responsible for internal friction are considered under the headings of thermal, magnetic, and atomic effects, with major attention given to atomic rearrangements such as diffusion effects, relaxation across interfaces, and the motion of dislocations. Studies of stress-induced ordering are discussed, and examples are given of such effects as in interstitial solid solutions in body-centered cubic lattices. Internal friction caused by plastic phenomena and the influence of such factors as cold-working and annealing are discussed in terms of dislocation theory. Brief discussion of thermoelastic and magnetoelastic effects is given. Extensive bibliography of over 100 recent papers completes this valuable and clearly written summary. D. E. Hudson, USA

494. Sharman, L. J., Sones, R. H., and Cragg, L. H., Effects of rate of shear on inherent and intrinsic viscosities of polystyrene fractions, *J. appl. Phys.* **24,** 6, 703–711, June 1953.

Paper deals with too-often neglected question of non-Newtonian flow in measurement of intrinsic viscosity of solutions of higher molecular weight (MW) polymers. Polystyrene fractions of MW 0.3×10^6 to 10^6 were dissolved in "good" to "poor" solvents. Apparent viscosity of these solutions was observed, with capillary viscometer, as a function of maximum rate of shear (at capillary wall), temperature, and concentration. Rate of shear was varied between 100 and 2×10^4 sec^{-1}. Apparent viscosity is, for this range of rate of shear, a linear function of shear rate for lower MW fractions, becoming curvilinear at lower shear rates with higher MW fractions. Approximate MW threshold for curvilinear behavior is established. Deviation from linearity is least for poor solvents and greatest for good solvents. Authors conclude that intrinsic viscosity of higher MW polymers is best determined in a poor solvent. Reviewer notes that the shear rates referred to may represent a fictitious concept in that they are established on a basis of Newtonian behavior but are used to represent conditions of non-Newtonian flow. This does not vitiate the conclusions drawn by the authors with regard to the effect of molecular weight and shear rate on intrinsic viscosity.
J. T. Bergen, USA

495. Vasil'ev, L. I., Some data on the conformity of relaxation and velocity characteristics in plastic deformation (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **89,** 3, 451–453, Mar. 1953.

496. Pao, Y.-H., and Marin, J., An analytical theory of the creep deformation of materials, *J. appl. Mech.* **20,** 2, 245–252, 1953.

Authors give a clear account of work by Soderberg, Odquist, Bailey, and others, and extend theory on following basis: (1) Total strain is separated into elastic, transient creep, and minimum rate creep components; (2) transient and minimum rate creep strains do not produce change in volume; (3) principal shear creep rates are proportional to principal shear stresses; (4) distortion strain energy is the determining factor affecting creep. Theory represents for the first time the phenomenon of creep recovery and may be used for varying as well as constant stresses. J. Heyman, England

497. Nitsche, R., Experimental techniques for the analysis of creep phenomena in artificial materials of organic origin (in German), *Schweiz. Arch.* **19,** 5, 139–148, May 1953.

Beginning with an example of a Plexiglas bolt used to reinforce a broken bone, author develops the requirements for the creep-testing of plastics and uses various examples drawn from European and American literature. Included are the effects of molecular orientation, type of material, kind and magnitude of stress, testing equipment, type of test specimen, conditioning of the specimen, measuring techniques, and analysis of the results. The paper stresses the factors likely to influence the results of creep tests and is of particular value to individuals not familiar with the behavior of plastics. A. G. H. Dietz, USA

Failure, Mechanics of Solid State

(See also Rev. 512)

498. Sinclair, G. M., and Dolan, T. J., Effect of stress amplitude on statistical variability in fatigue life of 75S-T6 aluminum alloy, *Trans. ASME* **75,** 5, 867–870, July 1953.

Results of rotating cantilever tests of 174 specimens were analyzed on the assumption that the logarithm of the number of cycles to failure was normally distributed. The data indicate that this assumption was approximately correct and that standard deviation decreased with increasing stress amplitude. On the basis of these conclusions it was possible to construct a composite S-N diagram showing lines of equal probability of failure.
J. A. Bennett, USA

499. **Yokobori, T., Fatigue fracture from the standpoint of the stochastic theory,** *J. phys. Soc. Japan* **8, 2, 265–268, Mar.-Apr. 1953.**

Results of fatigue tests in reversed direct stress are analyzed using statistical methods, reference being made to author's previous publications. A. M. Wahl, USA

500. **Karpenko, G. V., Corrosion fatigue limit** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **87,** 4, 617–620, Dec. 1952.

501. **Wells, A. A., The influence of welding on notch-brittle fracture,** Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 459, 15 pp., May 1953.

Author discusses conditions for initiation and for subsequent propagation of brittle fracture and the remedial measures that might extend the safe temperature range under static loading. He offers the following interpretation of experiments on spontaneous fracture after welding. If, in a stress-strain diagram, the slope of the plastic-flow curve above the yield point exceeds the slope of the cleavage-strength curve, then strain-hardening can raise the critical temperature for initiation of brittle fracture. In notched specimens under ordinary conditions, appreciable strain-hardening cannot occur until a state of general yield has been reached; for until then, very small local strains suffice to relieve the stress concentration. But during cooling after welding, the cooling regions are constrained by the cool regions, and the resulting relief of thermal stresses is equivalent to general yield. Consequently, a crack or notch that was present before cooling can initiate spontaneous brittle fracture during cooling. The discussion is mostly qualitative, but includes a calculation, by Griffith's formula, of stress levels necessary for crack propagation under several conditions. W. F. Brown, Jr., USA

502. **Boyd, G. M., The propagation of fractures in mild-steel plates,** *Engineering* **175,** 4538, 4539; 65–69, 100–102, Jan. 16, Jan. 23, 1953.

Simple analysis, not involving stress and strain or structure of metals and based only on assumption of constant fracture energy per unit fracture area, leads to shape of fracture front for so-called "brittle" fracture. Chevron pattern is deduced which agrees quantitatively with observed patterns. Paper further justifies use of same assumption in extension of Griffith theory to this class of fracture by Orowan [see AMR **6,** Rev. 1259].

R. B. Green, USA

Material Test Techniques

(See also Rev. 468)

503. **Green, L., Jr., High-temperature compression testing of graphite,** *J. appl. Mech.* **20,** 2, 289–294, June 1953.

Graphite cylinders placed between carbon blocks were tested under compression while heated by passing a heavy d-c current. The surface temperature was taken as an indication of the temperature of the cylinder. The short-time compression strength for AUF grade of graphite was found to increase with temperature (investigated up to 2000 C), quite similarly to the previously reported behavior of tensile strength for such materials [AMR 4, Rev. 3905]. In this range of temperature, the fractures are of a brittle type and creep does not influence the results. The view is expressed (and supported by photographs of typical fractures) that, at higher temperatures, deformation by creep is responsible for the stress relaxation observed and that the decrease of the short-time tensile stress for temperatures above 2500 C is due also to creep and, consequently, the location of the maximum is probably a function of the rate of loading. All experimental results are semi-quantitative in nature. An electron photomicrograph of a slice of AUF graphite is given which, according to the author, supports his view that the structure of polycrystalline graphite is not similar to that of ceramic ware.

S. Mrozowski, USA

504. **Ageeva, N. S., Zhukov, I. P., Isakovich, M. A., Sosedova, A. L., and Sukharevskiĭ, Yu. M., Electrical-mechanical *Q*-meter for measuring modulus of elasticity and ultra-audio losses in materials** (in Russian), *Zh. tekh. Fiz.* **22,** 6, 1029–1042, June 1952.

Mechanical part of apparatus is the resonance package. It consists of a bar specimen of certain length, divided into two equal parts. To each half of the bar is cemented a piezoquartz plate. Finally, the two piezoquartz plates are cemented to a common metal plate which is located at the midsection of the unit, dividing it into two symmetrical halves. The unit thus assembled makes up an ultra-audio resonance package which has longitudinal vibrations. The package is freely suspended horizontally at the midsection, or vertically at one of the free ends. When large losses are desirable, then this bar is made of any material having good resonance properties and at the ends of such a bar pieces of specimen material are cemented.

Electrical part consists of usual *Q*-meter. It is used for measuring electrical resistance losses in piezoquartz plates. Electrical resistance losses excite mechanical vibrations in the package. Thus capacity and frequency losses of piezoquartz plates are related to mechanical resistance of the bars and, therefore, they are also related to those of the specimen material. It is assumed that mechanical and electrical losses in quartz plates proper are small. The mechanical losses in layers of cement and suspension system are also small.

Measurements are taken when generator and electrical contour of the *Q*-meter are tuned to resonance frequence of the package.

Authors describe the theory of the apparatus and provide formulas and graphs for determining Young's modulus for solids. Shear modulus for rubber-type materials and decrement of damping can be computed. Necessary data are obtained from electrical measurements. Authors give results of measurements of Young's modulus for aluminum, steel, phosphor bronze, Plexiglas, Ebonite, babbitt, and barium titanate.

Also available is relationship between shear modulus and decrement of damping for rubber as a function of temperature and pressure. V. A. Valev, USA

Mechanical Properties of Specific Materials

(See also Revs. 467, 472, 493, 494, 497, 498, 503, 666, 670)

505. Case, S. L., and Van Horn, K. R., Aluminum in iron and steel, New York, John Wiley & Sons, Inc.: London, Chapman & Hall, Ltd., 1953, xii + 478 pp. $8.50.

This book is the first of a new monograph series sponsored by Alloys of Iron Research, an organization affiliated with The Engineering Foundation. It presents a concise but comprehensive summary of available literature and data on effect of aluminum on carbon steel and on simple and complex alloys of steel and cast iron. The book is divided into two parts, the first concerned primarily with the role of aluminum as a deoxidizer in manufacture of carbon steel, and the second part with aluminum as an alloying element in steels and cast irons.

The authors are to be commended for preparing an excellent treatise on this important subject. In particular, reviewer approves their practice of simply yet thoroughly explaining a particular phenomenon—e.g., aging of steel—before discussing the effect of aluminum on this characteristic. Documentation of the book also is excellent.

The first chapter introduces the role of aluminum as a deoxidizer in the manufacture of steel by giving a brief discussion of the thermodynamics of deoxidation and of methods of adding aluminum during manufacture. Chapters 2 and 3 discuss the effect of the deoxidation with aluminum on formation of oxide, sulphide, and nitride inclusions in steel. Such inclusions vary in size and distribution and may have either beneficial or detrimental effects, depending upon amount of aluminum used. The fact that aluminum, when used as a deoxidizer, raises the grain-coarsening temperature and therefore may be used to control austenitic grain size is discussed in chap. 4. The effect of aluminum on notch sensitivity of steels is covered in chap. 5 and the effect on aging of steels in chap. 6. In both of these chapters, the authors render great service to the reader by their excellent review of the phenomena of notch sensitivity and aging, respectively, before presenting and analyzing data pertaining to the influence of aluminum on these phenomena. Some other consequences of use of aluminum as a deoxidizer, including its effect upon deep-drawing steels and the effect of aluminum on hardenability, creep, etc., are discussed in chap. 7, the last of part I.

Foundation is laid in chaps. 8 and 9 for the discussion of iron-aluminum alloys in the remainder of part 2. In these two chapters authors present a brief but thorough treatment of metallurgy and manufacture of binary and complex iron-aluminum alloys. In chap. 10 is discussed the use of aluminum in heat-resisting alloys. Since 1930 it has been known that addition of up to 10% aluminum to iron-chromium and iron-chromium-nickel alloys commonly used in high temperature work may increase resistance to loss by scaling of these alloys severalfold. This increase in resistance apparently is due to reduction by aluminum of iron oxide formed at high temperature. The use of aluminum in permanent-magnet alloys, of which the iron-nickel-aluminum alloys are best known, is discussed in chap. 11. Chap. 12 treats the surface hardening of steel by nitriding and the function of aluminum in this process. Authors state that "hardest nitride cases consistent with satisfactory depth are obtained on steels containing at least 1% aluminum in addition to other alloying elements." The important use of aluminum for coating steel to obtain noncorrodible, nonscaling surface is treated in chap. 13. A surface layer of pure aluminum has been found to provide the best protection against atmospheric corrosion, whereas in resistance to scaling at high temperature a coating of iron-aluminum compound is more effective. Choice of process is determined by type of use, type of part to be coated, and by economic considerations. In the last chapter, miscellaneous uses of aluminum as an alloying element in iron and steel are mentioned, including use of aluminum in cast iron, transformer steel, tool steel, and nickel-base high-temperature steels for gas turbines, etc. W. E. Black, USA

506. Buĭnov, N. N., and Podrezov, L. I., Effect of plastic deformation on consecutive decay in aluminum alloys (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **88,** 4, 665–668, Feb. 1953.

507. Mima, G., and Imoto, S., Changes of internal friction and Young's modulus with heat-treatment of iron-chromium alloys, *Technol. Rep. Osaka Univ.* **2,** 201–208, Oct. 1952.

Internal friction of the sigma phase is larger than one of the alpha phase, and Young's modulus of the sigma phase is smaller than one of the alpha phase. This may be seen to be inconsistent with the hard and brittle nature of the sigma phase. Young's modulus of the sigma phase near 770 C is distinctly different from one near 660 C, and it is thought that the sigma phase might, moreover, be sectioned in two phases at a temperature.

From authors' summary

508. Smith, A. D. N., The effect of small amounts of cold-work on Young's modulus of copper, *Phil. Mag.* (7) **44,** 352, 453–466, May 1953.

The effect on Young's modulus of copper of small amounts of plastic extension (1–8%) and subsequent low temperature annealing (50–100 C) has been studied. The results confirm previous work that there is a reduction of about 11% in the modulus, the greater part of which is recoverable after prolonged annealing at 100 C. The reduction is attributed to the elastic oscillation of the relatively mobile screw components of dislocation loops, recovery being caused by the annihilation of such components in pairs by cross slip, as suggested by Mott (1952).

In an analysis of the recovery process it is assumed that the activation energy required to move the two screw components together is not unique but is distributed in a Gaussian manner about a mean. This mean value is found to be 25,000 cal/mole for O.F.H.C. copper extended by 1%, and 21,500 cal/mole for the same material extended by 8.4%.

From author's summary by R. Smoluchowski, USA

509. Mash, D. R., and Hall, L. D., Anelastic behavior of pure gold wire, *J. Metals* **5,** 7, 937–942, July 1953.

Grain boundary relaxation in spectrographically pure (99.9998 %) and commercial (99.98%) gold was studied by means of low frequency (N/C.P.S.) internal friction. Two discrete grain-boundary peaks were observed at 460 and 760 F in polycrystalline pure gold after heat treatment above 1200 F. Commercial gold showed only one peak regardless of heat treatment. Additional x-ray and metallographic evidence suggests that the peaks are associated with primary and secondary recrystallization, and that grain-boundary stability, as determined by relative grain orientation, is important in controlling grain-boundary relaxation characteristics. The effects of minute amounts of impurities in masking such characteristics were emphasized. A. D. Schwope, USA

510. Dike, K. C., and Long, R. A., Effect of processing variables on the transition temperature, strength, and ductility of high-purity, sintered, wrought molybdenum metal, *NACA TN* 2915, 26 pp., Mar. 1953.

Authors utilized tensile tests at various temperatures to evaluate effect of amount of swaging, recrystallization, and stress-relieving on tensile properties of molybdenum. Swaging reductions of 99% lowered the transition temperature range approximately 100 F below that for metal swaged only 35%. Recrystallization nullified the beneficial effect of swaging on transition temperature range. At room temperature, swaging to 99% increased the ultimate tensile strength only 13% over that of molybdenum swaged 35%. Stress-relief anneal caused reduction of 3 to 6% in tensile strength. Ductility of a swaged metal at room temperature was improved considerably by swaging 50% or more. Other data are furnished as to grain size, microstructure type of fracture, and chemical analysis.

G. M. Sinclair, USA

511. Torrado Varela, M., Some considerations on the behavior of metals at low temperatures (in Spanish), *Técn. Metalúrg.* **9,** 78, 37–45, Feb. 1953.

Flying in the stratosphere implies the knowledge of physical

and chemical conditions and of their effects on metallic materials used for the construction of the airship. These conditions and effects are reported and discussed with reference to previous research and publications, especially crystalline state of metals, anisotropy and its effect at low temperatures, possible changes of crystalline form of various metals (steel, aluminum, and magnesium alloys). Results of investigations and tests show: Less corrosion, smaller resilience; higher modulus of elasticity and ultimate strength (with some exceptions); increased dynamic resistance; higher limits of fatigue; changes of physical properties caused by stratospheric cooling are reversible if gradually exposed to normal temperatures, with exception of tin which disintegrates; certain metals of noncubical crystalline state (as zinc and cadmium), if exposed to thermic cycles, are subjected to permanent changes when brought to normal temperature. Special credit in the research is given to P. Litherland Teed, De Haas, and Hatfield. At the end, suggestions are made for further studies and research. J. J. Polivka, USA

512. **Krushchov, M. M., and Babichev, M. A., Resistance to abrasive wear and the hardness of metals** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **88,** 3, 445–448, Jan. 1953.

513. **Davis, R. E., and Troxell, G. E., Properties of concrete and their influence on prestress design,** Proc. Western Conf. Prestressed Concrete, Univ. of Calif., Los Angeles, Nov. 1952; 39–49, Jan. 1953.

Paper contains practical information that should be of particular value to those designing mixes for prestressed concrete. The author comments as follows on the shrinkage and creep characteristics of concrete as they relate to prestressed design: The concrete must be uniform, from point to point, throughout the member, having a low shrinkage and creep value. In order to achieve uniformity in prestressed concrete, a concrete mix which is more plastic and sticky than ordinary concrete is required; otherwise excessive bleeding and segregation may occur.

Shrinkage and creep in concrete are closely associated phenomena and are related to the removal of absorbed water from the hardened cement gel; other factors being equal, shrinkage is approximately proportional to the volume of water used, creep being proportional to both the volume of cement paste and water-cement ratio. The character, grading, and maximum size of aggregate also have an important bearing on shrinkage and creep: the more dense the aggregate, the larger the maximum size of aggregate, the less shrinkage. Author also points out that air entrainment, properly introduced, in amounts ranging from 3–5% will increase workability, reduce bleeding, and reduce somewhat segregation due to vibration. M. M. Lemcoe, USA

514. **Khodzha-Ĭnatov, A. A., New type of hydrotechnical concrete** (in Russian), *Gidrotekh. Stroit.* no. 11, 21–22, Nov. 1952.

515. **Tikhonov, V. A., Effect of air-retaining admixtures on the water permeability and frost resistance of cement solutions** (in Russian), *Gidrotekh. Stroit.* no. 11, 14–16, Nov. 1952.

516. **Rouse, P. E., Jr., A theory of the linear viscoelastic properties of dilute solutions of coiling polymers,** *J. chem. Phys.* 21, 7, 1272–1280, July 1953.

This mathematical treatment coordinates the motions of different parts of a polymer molecule by the concept of submolecules, portions of the chain molecule long enough for the separation of its ends to approximate a Gaussian probability distribution. A velocity gradient disturbs this distribution and stores energy in the system. The coordinated thermal motions of the molecule tend to cause the disturbed configurations to drift back to the equilibrium distribution. Equations are derived by which relaxation times, complex viscosity, and complex rigidity can be calculated from steady flow viscosities of the solution and the solvent. The theory is only applicable to solutions so dilute that one molecule does not interact with another.

L. Nielsen, USA

517. **Ratner, S. B., Abrasion index for rubber and its relation to the coefficient of friction** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **87,** 5, 743–746, Dec. 1952.

518. **Haward, R. N., The strength of plastics and glass. A study in time-sensitive materials,** London, Cleaver-Hume Press; New York, Interscience Publishers, Inc., 1949, vii + 243 pp. $5.50.

This book is of interest to any engineer or scientist concerned with the manufacture and use of plastics or glass. Although the time-sensitive nature of these materials has long been known, many users are still unaware of the magnitude of the time effect or the existence of engineering methods for its evaluation. It is clearly shown in the text that long-time tensile strength is of primary importance in the engineering design of load-bearing structures made of plastics or glass, or a combination of plastics and glass. Fortunately, the author has placed his main emphasis on the presentation of known facts. Theories are presented only when accompanied by experimental data.

The text considers first the fundamentals involved in the various strength relations and then follows with chapters on the static strength of plastics, static strength of glass, deformation of plastics and glass, hardness, and impact. The concluding chapter deals with "Some characteristic properties of complex materials." The data are well documented and the references will be of great value to the practical engineer, research worker, or plastics technician. R. H. Carey, USA

Mechanics of Forming and Cutting

(See also Rev. 620)

519. **Sachs, B., An analytical study of the die-casting process,** *ASTM Bull.* no. 192, 27–37, Sept. 1953.

This is an excellent mathematical correlation of all significant factors of the die-casting process prior to solidification of the casting. It includes a table of equations for pressures, velocities, accelerations, time and casting porosity as functions of unique machine, metal, and die characteristics. The theoretical analysis supports the well-known sensitivity of casting porosity to gate area in direct-air gooseneck machines. A comparison is made of the performance of 10 types of machines in producing the ASTM test casting. Die casters and production designers will want this paper in their files. L. V. Colwell, USA

520. **Schmidt, A. O., Workpiece and surface temperatures in milling,** *Trans. ASME* **75,** 5, 883–889, July 1953.

Paper describes both temperature distribution and surface temperature of a workpiece during milling operation. For temperature measurements at sufficient distances from the surface, thermocouple and potentiometers were employed in the usual way. In the determination of maximum surface temperature, the milling cutter was replaced by an oxyacetylene torch traveling over the work surface at a rate the same as the feed. Its rate of heat liberation was so adjusted as to give a temperature gradient

in the workpiece identical to that produced during the actual cutting operation. Surface temperatures determined in this manner have been found to be unusually high. In many instances, they were above 2000 F when quenched-tempered SAE 1090 steel was being milled. It was also found that the maximum surface temperature would be lower with lower cutting speeds, although the average temperature of the workpiece was higher, since a higher percentage of heat went into the workpiece at the slower rate of separation of chips. Results include temperature values for machining gray cast iron, brass, 24S-T aluminum alloy, and magnesium alloys.

Computation of the so-called "surface-layer temperature" of the workpiece was also attempted. In doing this, author assumed that heat in the workpiece was initially confined to a thin deformed layer which was taken to be 0.004 in. thick for steel at the speeds and feeds used in the investigation. Temperatures so calculated were higher than those determined by the flame technique.

Reviewer believes that the method of using an equivalent heat source for the determination of surface temperature is, in principle, a sound one. However, with reference to the computation of the surface temperature, the concept of a uniform temperature across a thin deformed layer is difficult to conceive.

B. T. Chao, USA

521. Kostrov, B. D., Study of heat phenomena in metal cutting (in Russian), *Stanki i Instrument* no. 3, p. 27, Mar. 1953.

522. Kazakov, N. F., Investigating the process of high-speed metal cutting by using an apparatus of low inertia (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 12, 1769–1781, Dec. 1952.

523. Chisholm, S. F., Lubricants for the cold working of non-ferrous metals, London, Inst. Metals, "The cold working of non-ferrous metals and alloys," 27–44, 1952.

The processes of cold rolling, press drawing, and tube and wire drawing are discussed as to lubricant requirements. Suitable types of lubricants are suggested. It is emphasized that the coefficient of friction and film strength are the two most important factors. In general, mineral oils with certain additives are recommended. Organic phosphorus compounds as film strength improvers, synthetic esters, and fatty oils as lubricity improvers, detailed suggestions, and discussion are given for each of many press and draw-bench operations. L. V. Colwell, USA

Hydraulics; Cavitation; Transport

(See also Revs. 417, 421, 595, 669)

524. Boyer, M. C., and Lonsdale, E. M., The measurement of low water velocities by electrolytic means, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 455–462, 1953.

On the basis that the electrical resistance between electrodes immersed in flowing water decreases with increasing flow, an electronic velocity meter has been developed for use in water at slow speeds. The author indicates that it should also be of value in recording turbulent velocity components, although this has not been established. He feels, and the reviewer concurs, that the instrument needs considerably more development before its value and accuracy under all conditions are established.

P. Donely, USA

525. Priss, L. S., Theory of rotational-vibrating viscosimeter for highly viscous fluids (in Russian), *Zh. tekh. Fiz.* **22,** 6, 1050–1061, June 1952.

526. Lászlóffy, W., Szesztay, K., and Szilágyi, J., Estimate of surface water resources (in Hungarian, with French, German, Russian, and English summaries), *Vízügyi Közleményei* no. 1, 3-77, (4)–(14), 1953.

This subject, part of a postgraduate course for engineers in hydrology, is comprehensively treated, with practical examples of Hungarian rivers and extensive references to determine the country's water resources for optimum utilization. Graphical methods and their theoretical basis are presented for determining the rating curve of river flows when data (river levels at known sections at given time intervals) are insufficient, scattering, or inadequate. The evaluation of discrepancies, often due to disturbances such as flash flood, backwater, shifting channel, unsteady flow, ice, etc., is pointed out, thus enabling engineers who are making the rating curve to improve their approach and to instruct the technicians taking the data. A. Hollander, USA

527. Kampé de Fériet, J., and Kotik, J., Surface waves of finite energy, *J. rational Mech. Anal.* **2,** 3, 577–585, 1953.

Authors explain the new solution for two-dimensional gravity waves given in *Comptes Rendus,* July 1952 [see AMR **6,** Rev. 1304]. It must be pointed out that present paper is more extended than the other one, making it easier to follow the development of the procedure. G. Supino, Italy

528. Becker, E., Analogies between surges and shock waves (in German), *Ing.-Arch.* **21,** 1, 42–54, 1953.

Author refers to fundamental treatment of analogies made by E. Preiswerk ["Aerodynamic methods used on waterflow in open channels" (in German), Diss. Zürich, 1938] and emphasizes discrepancies which can be divided into two groups: (1) Caused by different dimensional conditions, already mentioned by Preiswerk; (2) caused by different dimensional conditions, i.e., surges have vertical velocity components and action of surface tension and bottom friction, which do not exist in shock waves in gases.

Author deals with group (2), especially for shallow water, and shows on basis of momentum equation that bottom friction only causes slight ascent in water surface behind surge front. Effect of vertical velocity component and surface tension is derived from Euler equations, velocity being developed into power series. Solitary wave problem has been prototype. General results are that only form of surge front is influenced. In very shallow water (depth less than 0.38 cm), small surges are formed as capillary waves. In greater surges, instability causes formation of surface roller, in which energy now is dissipated. In front of surge, capillary waves are formed, but here having only small significance. Vertical velocity components have practically no influence. In water deeper than 0.38 cm, small surges have no surface roller and the energy dissipates in capillary waves in front of surge. Vertical velocity components cause gradual elevation of water surface before surge front. Elevation can be calculated approximately by formulas given in paper. Capillary waves mentioned are supposed on this elevation. Greater surges have surface roller (zone of eddy motion) and capillary waves disappear almost completely. Gradual elevation before surge front is covered by surface roller. In this case we have the best analogy with shock waves in gases. Theoretically developed results have been confirmed by experiments in Max-Planck Institute, Göttingen. H. T. Kristensen, Sweden

529. Pattantyús, G. A., Fluid flow through concrete channels (in Russian), *Acta Techn. Hung. Budapest* **6,** 3/4, 331–350, 1953.

First part of paper gives results of experimentally determining head loss coefficients for variously shaped, open closure and con-

trol shafts in a system of concrete-covered conduits supplying a big power plant with cooling water. Advantages of a rounded shape and free-flow conduits are proved by numerical comparison.

In second part, author computes maximum rise of water level in pumping shafts of a conduit system in case of abruptly stopped pumping. He shows how to substitute a conduit system with one pumping well (whose water-level oscillations have been computed) for complex systems of conduits, control and closure shafts, and pumping wells, both systems being energetically equivalent. A. Puzanov, Czechoslovakia

530. **Leopold, L. B., and Maddock, T., Jr., Relation of suspended-sediment concentration to channel scour and fill,** Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 159–178, 1953.

Authors refer to a previous study in which they showed that for a given station on a stream, surface width, depth, mean velocity, and rate of transportation of suspended load are all power functions of the rate of flow Q in which the exponents of Q are denoted, respectively, by b, f, m, and j. Data are presented showing that for a given value of b, j is a function of m/f. A similar relation was derived which, in the authors' words, is: "For constant discharge and width, an increase in suspended load is accompanied by an increase in velocity at the expense of depth."

Observations at a station on each of three streams in Southwestern U. S. are presented to demonstrate the applicability of the latter relation. Arguments are presented to show that the observed changes at a station are the result of and not the cause of the change in transportation rate. Authors conclude that changes in velocity-depth relationships are due primarily to changes in channel roughness rather than in slope.

V. A. Vanoni, USA

531. **Cappus, P., Flood calculations by the unit hydrograph method (Alrance)** (in French), *Houille blanche* **8,** no. A, 159–167, Mar.-Apr. 1953.

532. **Einstein, H. A., and Barbarossa, N. L., River channel roughness,** *Trans. Amer. Soc. civ. Engrs.* **117,** 1121–1132, 1952.

Authors have formulated method for determining the relationship between stage and discharge in a given reach of river. The method does not require an estimate of the bottom roughness, i.e., Manning's n.

The total shear on the river bed is assumed to be composed of two components: The shear due to the grain roughness, and the shear due to bed irregularities, e.g., sand bars. A basic assumption is that the grain roughness and bed irregularities are evenly distributed over the boundary. Authors then let the additional shear due to irregularities be a function of the sediment transport, and this relationship is determined from actual river measurements.

The additional information required, besides the slope and river cross section as a function of stage, is a mechanical analysis of the bottom sediments. From the resultant computations, Manning's n may be determined for the various stages or discharges. H. G. Farmer, Jr., USA

533. **Gibrat, R., Maximum flood discharge and probability calculations** (in French), *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, in 4 vols., vol. II, 643–660. $48 per set.

Author's law of proportional effect for determining the probability of flood discharge, proposed about 20 years ago, is recalled. This law employs all water-discharge observations, not only the largest. A comparison is made, for a practical example, with the ancient empirical Füller law for the most probable maximum flood. A new method is then described, due to F. I. Gumbel, and based on the consideration of largest values of flood, whose statistic distribution is shown to follow asymptotically a simple law of probability, independent of the general law. Gumbel's theory gives a justification and generalization of the Füller formula; a numerical application leads to results close to those derived from the law of proportional effect. D. Citrini, Italy

534. **Ponsar, Y., Recent investigations on siphons and derived equipment** (in French), *Houille blanche* **8,** no. A, 144–151, Mar.–Apr. 1953.

Author introduces three apparatuses derived from the siphon which can be used in many different ways.

(1) A partially primed siphon in which the degree of vacuum is controlled by the level of the overflowing water in such a way that this level remains constant. This apparatus makes it possible to regulate a whole range of constant discharges with highly variable upstream and downstream levels. A prototype of this apparatus discharges up to 240 liters per sec at the filter outlet of a water-purifying station.

(2) Simplified ejector placed at the top of a siphon (of the adjustable vacuum type as in (1)). Its design is such that it entrains air in much the same way as a standard type ejector, but with a far higher efficiency.

(3) An improvement made on constant upstream level siphon consists in reducing the cross section of its upstream branch at the same level as an air intake slit made directly in the wall and around which is placed a four-sided box, or sort of balcony. The water level in this balcony regulates the entrance of air. With this apparatus, the upstream water level can be maintained constant for a wide range of discharge variations, going from the maximum discharge to $^1/_{12}$ instead of $^1/_3$.

From author's summary

535. **Boshoff, W. H., Characteristics of a spinning-disk liquid sprayer,** *Instn. mech. Engrs. Proc.* (*A*) **166,** 4, 443–446, 1952.

Author describes an attempt to increase the output of a spinning-disk sprayer without sacrificing the homogeneous drop-size characteristics found by previous investigators. A disk sprayer $14^1/_4$ inches in diameter was designed, and the characteristics were determined by feeding various quantities of water centrally onto the disk and by noting the resulting drop sizes and their distribution over a range of disk speeds from 600 to 2000 rpm.

The critical flow rate for the production of uniform-size drops is in the range 6–22 cm³/sec, and the size of drops produced is inversely proportional to the speed of the disk. The product of drop diameter and peripheral velocity of the disk is approximately constant and varies with the smoothness of the surface of the disk rather than with the rate of liquid flow.

Above the critical flow rate the homogeneity of the drops disappears and a wider range of sizes is observed. The distribution and sizes of the drops are independent of the rate of liquid feed over a range of from 22 to 110 cm³/sec, the size of the majority of drops being dependent on the peripheral speed of the disk. Above that range the liquid comes off the disk in a sheet, in which little or no breakup of the liquid takes place.

It is concluded that spinning disks of large diameter will produce drops of uniform size, even at relatively low rotational speeds. From author's summary by L. Talbot, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 417, 422, 553, 570, 575, 576, 584, 588, 593, 616)

536. Sternberg, E., and Sadowsky, M. A., Axisymmetric flow of an ideal incompressible fluid about a solid torus, *J. appl. Mech.* **20,** 3, 393–400, Sept. 1953.

Exact solution in open form is given for this problem in which a uniform flow is directed along the axis of the torus. Toroidal coordinates are used in the solution of Laplace's equation which comes out in terms of Legendre functions of fractional order or alternately in terms of complete and incomplete elliptic integrals of the first and second kind. It is found that the first-order solution is simply that for the ring doublet which corresponds to a torus whose section is very close to a circle. Authors point out that this problem has been treated by Streeter. Results of a single calculation are presented.

Reviewer feels the paper would have been enhanced by comparison with approximate solution to indicate the error involved in neglecting the terms which are found necessary to give a torus of exactly circular cross section, inasmuch as their series solution is found to converge rapidly.

J. P. Breslin, USA

537. Tetervin, N., Study of stability of the incompressible laminar boundary layer on infinite wedges, *NACA TN* 2976, 41 pp., Aug. 1953.

Using an approximate method, Schlichting calculated for a laminar boundary layer in a region of decreasing pressure that a thick velocity profile can be more stable than a thin profile, although the velocity at the edge of the boundary layer and the pressure gradient are the same in both cases. The present author shows that Hartree's numerical solutions of the boundary-layer equations for the flow over infinite wedges confirm Schlichting's result. The wedge flows, however, satisfy a basic assumption of the Schlichting method that the velocity profile is a single-valued function of the local effective pressure gradient, and so provide only a partial verification of the Schlichting method.

In addition, it is shown that a change in boundary-layer thickness has the same effect on the stability and local roughness Reynolds number when the Schlichting single-parameter family of velocity profiles is replaced by the Hartree single-parameter family of velocity profiles. A. R. Mitchell, Scotland

538. Long, R. R., Steady motion around a symmetrical obstacle moving along the axis of a rotating liquid, *J. Meteor.* **10,** 3, 197–203, June 1953.

General solution is given in a series form. Author says that even for a sphere moving in an unlimited fluid, the determination of the coefficients of the series, so as to annul the upstream waves, is prohibitively complicated. The series is examined for the case of flow around an obstacle moving along the axis of rotating cylinder of finite radius. It is found that oscillating solutions exist only below a certain value of Rossby number and higher modes are possible within certain ranges of Rossby number. Experiments were conducted by moving an obstacle along the axis of a long cylinder of rotating water. The waves appeared only behind the obstacle and the wave length corresponded approximately to the fundamental mode. M. S. Uberoi, USA

539. Sowerby, L., The couple on a rotating spheroid in a slow stream, *Proc. Camb. phil. Soc.* **49,** part 2, 327–332, Apr. 1953.

An oblate spheroid rotates about its axis of symmetry which is parallel to the stream direction. Author uses the Oseen approximation to the equation of motion for transverse flow of a viscous fluid in cylindrical coordinates. A transformation to spheroidal coordinates permits a separable solution to be found for the transverse velocity in terms of spheroidal wave functions, and an expression is then obtained for the couple necessary to maintain rotation. The results reduce to those of Jeffery [*Proc. Lond. math. Soc.* (2), **14,** 327–338, 1914–1915] for zero stream velocity. Numerical values of the couple acting in the limiting case of a disk rotating about its central normal are calculated for several Reynolds numbers, showing a nonlinear increase with this parameter. T. F. O'Brien, USA

540. Torda, T. P., Wake of a flat plate in laminar incompressible flow, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 613–629, 1953.

The equations of momentum and energy balance are integrated across the wake by assuming a solution for the tangential velocity with sufficient arbitrariness to satisfy the various boundary conditions. The resulting equations relate the wake thickness to a function defining the downstream decay of this tangential velocity. A numerical example is given. The results differ in several respects from the previous work of Goldstein and Tollmien, and experiments are planned to determine whether the assumed solution is adequate. W. V. R. Malkus, USA

541. Truckenbrodt, E., Velocity potential of the lifting plane for incompressible flow (in German), *ZAMM* **33,** 5/6, 165–173, May/June 1953.

Author assumes that the lifting plane consists of single vortexes of horseshoe shape and deduces in an obvious way a simple expression for the velocity potential that is equivalent to the known formulas of J. M. Burgers, Th. von Kármán, and L. Prandtl. From author's summary

542. Rabineau, B. A., Determination of velocities on and near ducted slender bodies of revolution at 0° angle of attack in incompressible flow, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 243–265, 1953.

A method is presented for determining to a second or higher order of approximation the velocities on and near the surface of a ducted slender body of revolution such as a jet engine nacelle.

The stagnation streamline and the stream function, together with their first and second derivatives near the stagnation point, are determined. Their analytical expressions are given as functions of the body contour and of the duct inflow velocity ratio.

An indirect check by comparison with NACA experimental data is presented. From author's summary

543. McNown, J. S., Hsu, E.-Y., and Yih, C.-S., Applications of the relaxation technique in fluid mechanics, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 223, 25 pp., July 1953.

A clear explanation of computation procedure is given for two-dimensional and axisymmetric potential flow. Attention is paid to boundary conditions for solid walls and for free surfaces in various types of efflux and in seepage through porous media. Representative examples illustrate the method described. Useful remarks, concerning the possibilities and limitations, are given from authors' practical experience.

H. J. Schoemaker, Holland

544. Krzywoblocki, M. Z. v., On vortex equation in isentropic flow, *J. phys. Soc. Japan* **8,** 3, 387–389, May-June 1953.

The equation of a vortex in an isentropic flow in the hodograph

plane is rederived for conditions identical with those of Ringleb [*ZAMM* **20**, 4, 185–198, 1940]. The result differs from that of Ringleb and is shown to yield a complete analogy to the incompressible flow. A. H. Sacks, USA

545. **Stewartson, K., On the flow downstream of separation in an incompressible fluid,** *Proc. Camb. phil. Soc.* **49**, part 3, 561–569, July 1953.

Flow along a wall under adverse pressure gradient is analyzed at and after the point where skin friction goes to zero. Laminar boundary-layer equations are used, and recent solution of Goldstein [*Quart. J. Mech.* **1**, 43, 1948] is the starting point. Main part of paper is discussion of one of Goldstein's conclusions about flow downstream of separation. It is shown that, under assumption that along the free streamline fluid stress is zero, flow cannot stick to wall. This verifies experimental result. Two cases for free streamline are then discussed. In the first, a continuous pressure gradient, an infinite number of solutions of the boundary-layer equations are possible, and free boundary may be chosen with considerable arbitrariness—possibly it could be determined by inviscid flow solution. In the second, zero pressure gradient downstream of separation cross velocity is discontinuous, but this is not a serious limitation. Velocity along streamline is given as a known function of velocity and velocity gradient in inviscid flow outside of boundary layer.

Author hopes that result for second case will have application in the theory of interaction between shock waves and laminar boundary layers. Reviewer believes it might also be useful in flows with steady cavities. W. D. Baines, Canada

Compressible Flow, Gas Dynamics

(See also Revs. 420, 423, 424, 528, 569, 584, 586, 591)

546. **Zaldastani, O., The one-dimensional isentropic fluid flow,** Advances in appl. Mech. **III**, 21–59, 1953. [Academic Press, Inc., N. Y.]

A constructive review of the one-dimensional nonsteady flow of a nonconducting, nonviscous fluid is presented. The form of the pressure-density relation is assumed known, but is arbitrary with some emphasis given to a generalized polytropic form. Well-established procedures are extended to provide a linearizing hodograph transformation of the basic flow equations. The general case is reduced to $Z_{vv}^* - Z_{uu}^* = N(v)Z^*$ where u, v are the independent parameters in the hodograph plane. $N(v)$ is dependent on the state through the parameter $v = \int a d\rho/\rho$, where a is sonic velocity. If $N(v) = \text{const}/v^2$, a generalized polytropic fluid is implied, while the equation becomes that considered by G. Darboux ["Leçons sur la théorie générale des surfaces," vol. II, Paris, Gauthier-Villars, 1915]. In general, a procedure for obtaining a series solution is outlined with Darboux's equation in particular, indicating solutions in terms of hypergeometric functions. The initial value problem is reviewed, following H. M. Martin's solution ["The rectilinear motion of a gas," *Amer. J. Math.* **65**, 391–407, 1943] of Riemann's method and also by the characteristics method as developed by R. von Mises ["One-dimensional adiabatic flow of an inviscous fluid," *Navord Rep.* 1719, 1951]. In addition, consideration is given to the patching problem along singularities. In conclusion, several familiar applications are discussed.

The survey is valuable in indicating the possibilities of an analytical solution in contrast to the geometrical characteristics solution. N. A. Hall, USA

547. **Kestin, J., and Zaremba, S. K., One-dimensional high-speed flows,** *Aircr. Engng.* **25**, 292, 172–175, 179, June 1953.

This interesting paper discusses one-dimensional gas flow with friction introduced as tangential stress along wall. Differential equation for square of Mach number is discussed, in particular its singular points, which must lie on line $M = 1$. If channel profile has no point of inflection, the sonic point is the only singular point, situated downstream of the throat in divergent region. In case of friction, closed trajectories cannot exist. If convergent-divergent channel profile has point of inflection, a second singularity occurs—either a spinal point, in which case no essential difference with frictionless flow is found except for certain regions where influence of frictions outweighs area change and where flow pattern for sufficiently high inlet Mach numbers is the same as for constant area pipe, or (but less likely) a nodal point. Then a continuous change from supersonic to subsonic flow is possible, with a varying range of exit Mach numbers. Finally, the case of a single singular point, coinciding with point of inflection of nozzle profile, is considered, which, however, can hardly occur in practice. R. Timman, Holland

548. **Loewner, C., Conservation laws in compressible fluid flow and associated mappings,** *J. rational Mech. Anal.* **2**, 3, 537–561, 1953.

Author's results are developed in general form but are best described in application to steady irrotational plane flow. Conservation law is any equation $[\xi(u, v)]_x + [\eta(u, v)]_y = 0$ implied by plane flow equations. Then $\xi dy - \eta dx = d\chi$ is an exact differential. For independent pairs of functions χ, author derives series of theorems about type of first-order system of partial-differential equations characterizing mappings of xy onto $\chi_1\chi_2$ plane. By taking χ_1 to be stream function and making various choices for χ_2, he derives several inequalities of following form for purely subsonic circulation free flow parallel to the x-axis at infinity. (1) $\int_B \varphi dy \geqq u_\infty A$, where φ is velocity potential, A profile's area, B its boundary. (2) For flow at zero incidence about a symmetrical profile, $\int_B p(x)y(x)dx \leqq p_\infty A$, where p is pressure. J. H. Giese, USA

549. **Britten, K. H. V., The use of influence factors in problems of fluid flow,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2441, 13 pp., Apr. 1947, published 1952.

Paper is a rigorous derivation of some empirical formulas developed by Thom [AMR **6**, Rev. 2848] for the numerical solution of subsonic-compressible-flow problems. In particular, for two-dimensional flow past a body in a wind tunnel, a formula for the "influence factor" is found. The influence factor is essentially the difference at infinity between the velocity potentials for compressible and incompressible flow.

One of Thom's formulas is shown to be true only in a limiting case. A numerical comparison between the true and approximate formulas is given. R. C. Roberts, USA

550. **Pai, S. I., Supersonic rotational flow over two-dimensional ogives,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 303–317, 1953.

Author determines the linearized supersonic rotational flow past two ogives differing slightly from a plane wedge; the first has a sinusoidal surface of small amplitude and the second a blunt nose. For each shape he compares the perturbed field found on the assumption of irrotational flow with the corresponding rotational field. The sinusoidal ogive has the original wedge slope at the nose and the basic disturbance is altered very little by the effect of rotations; but the perturbed velocity distribution, which is influenced by the reflection of the disturbance at the attached

shock, can be changed by as much as 20% by the effect. On the blunt-nosed wedge, the effect of rotation is still more marked and must be taken into account throughout the whole perturbed field. Maurice Holt, England

551. Fenain, M., Approximation of the equations governing the flow of a gas. Application to two-dimensional nozzle (in French), *Rech. aéro.* no. 33, 11–28, 1953.

The substitution of an approximate law for the exact compressibility law means replacement of the real gas by a fictitious gas which, in a well-defined region, behaves nearly as the real one. Author gives a survey of different approximations of the compressibility law and their influence on the solution of flow problems in the transonic region. Five different approximations are discussed in detail: three depend on two parameters and two on one. The different laws are compared in three diagrams: stream density vs. velocity, density vs. velocity, pressure vs. density (the critical values are taken as reference values). The approximations which come closest to the behavior of a real gas are used for the computation of the flow in a two-dimensional nozzle. I. Flügge-Lotz, USA

552. Dawson, L. G., Flow changes in gases in which mass and impulse are conserved, *Aero. Quart.* **4,** part II, 193–204, Feb. 1953.

By setting up complex expressions of weight flow, impulse, total temperature, static and total pressure as a function of velocity only, curves are plotted which allow determination of changes in the state of a gas flowing in a duct of constant area. The method is applied to normal shocks with and without heat addition and subsonic combustion. Furthermore, it is extended to oblique shocks.

It appears to reviewer that the geometric interpretation of the method by means of the pressure-velocity diagram of compressible flow would have increased its usefulness. As reviewer showed in his paper, "The application of the pressure-velocity diagram of compressible flow to the design of supersonic ramjets" [*Tech. Rep.* F-TR-2183-ND, Headquarters Air Materiel Command, Wright Field, Feb. 1948], this diagram is an excellent tool for solving problems of the kind described by Dawson, even including changes in duct area. Dawson's analysis improves the accuracy and simplifies the procedure in the case of constant area ducts. The application of Dawson's method to oblique shocks may be of academic interest only. H. J. Ramm, USA

553. Goldsworthy, F. A., On the flow in a high-pressure valve, *Proc. roy. Soc. Lond.* (*A*) **218,** 1132, 69–87, June 1953.

A theoretical study is made of the transient flow in a valve and its dependence on speed of opening, pressure ratio, and valve design. By making idealizing assumptions concerning the valve shape and boundary conditions, the one-dimensional time-dependent flow is shown to be mathematically equivalent to the flow of air ahead of an expanding sphere for which a solution (by G. I. Taylor) is known. Three types of flow are examined and flow parameters plotted: (1) For low pressure ratios, the flow will be subsonic throughout the valve. (2) At a critical pressure ratio, which depends on the speed with which the valve is opened, the flow at the throat will become sonic. (3) At higher pressure ratios, the flow will be supersonic in a portion of the valve.
L. H. Schindel, USA

554. Hadlatsch, P., Viscous gas flow through throttle valves and reflection of surging shock waves of high amplitudes I, II (in German), *ZVDI* **95,** 17/18, 20; 503–510, 706–711, June 1953.

A general flow equation for the viscous flow of compressible fluids through arbitrary throttling devices is derived with the help of the fundamental laws of gas dynamics. From this equation the effect of compressibility on the pressure ratio and the entropy increase becomes clear. The order of magnitude of a flow number, which is based on a single parameter of the calculations, is determined from similarity considerations. In this way a systematic study of the flow through arbitrary throttling devices is possible. A work sheet can be formulated from the developed theory which, together with three dimensionless parameters (namely, the pressure ratio, Mach number, and an entropy function), enables one to make investigations of steady as well as unsteady throttled flows. In the process, boundary conditions for a surging shock wave at the throttling position are satisfied. The method is illustrated by three basic examples and, thereby, demonstrates among other things how to calculate the gas-exchange process in a high-speed combustion engine—especially in two-stroke and loaded four-stroke motors with exhaust gas turbines. S. Ostrach, USA

555. Thomas, T. Y., On the problem of separation of supersonic flow from curved profiles, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc. 47–53, 1953.

See AMR **7,** Rev. 219.

556. Wu, C.-H., Subsonic flow of air through a single-stage and a seven-stage compressor, *NACA TN* 2961, 32 pp., June 1953.

This paper investigates the air flow through a single- and a seven-stage axial compressor according to a method recently developed in another paper by the same author for solving the steady flow of a nonviscous fluid along a relative stream surface between two adjacent blades in a turbomachine. A symmetrical velocity diagram at all radii is assumed. Solutions are obtained by the relaxation method and some are checked by the matrix method.

It is found that the air moves radially inward in the inlet guide vanes and the rotor and outward in the stator. This motion occurs for the single-stage compressor and for the first stage of the multistage compressor. Throughout the rest of the multistage compressor the radial flow is of the same oscillatory type but with a decreasing amplitude and superimposed on a mean line which follows the general shape of the walls. For an engineer, this analysis requires considerable mathematical effort and its results check very well with a simpler approximate solution obtained previously by the same author in another paper by assuming simple sinusoidal radial flow paths. It gives an analysis of the complex flow conditions associated with the symmetrical diagram flow pattern through an axial compressor.
H. E. Sheets, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 537, 545, 631, 633, 656)

557. Ito, H., Laminar boundary layer with large temperature difference, *Rep. Inst. high speed Mech., Tōhoku Univ.* **3,** 23–49, Mar. 1953.

Part I purports to give an exact solution for boundary layer in a gas analogous to Falkner-Skan solution for incompressible fluid. In part II, this is used for solution of more general cases by integral methods. Unfortunately, stream function introduced by the author does not enable equation of continuity to be satisfied automatically because of dependence of free-stream density with downstream distance. C. C. Lin, USA

558. **Tetervin, N., and Levine, D. A., A study of the stability of the laminar boundary layer as affected by changes in the boundary-layer thickness in regions of pressure gradient and flow through the surface,** *NACA TN* 2752, 83 pp., Aug. 1952.

Approximate calculation of critical Reynolds number shows that an increase in boundary-layer thickness in a region of favorable pressure gradient can increase the stability of the boundary layer. J. D. Cole, USA

559. **Eichelbrenner, E. A., An approximate method of calculation of the laminar compressible boundary layer for external pressure gradient, temperature law at the wall, and for any Prandtl number** (in French), *Rech. aéro.* no. 34, 3–10, July-Aug. 1953.

The flow in the compressible laminar boundary layer is determined by two partial-differential equations, if Crocco's representation is used. Instead of computing the velocity u and temperature T as functions of x (coordinate along the wall) and y (normal to the wall), Crocco suggested computing the shear stress τ and the temperature T as functions of x and u. In the case where the pressure gradient of the external flow is zero, solutions of the system of partial-differential equations are known (e.g. Crocco, Chapman and Rubesin, Bouniol and Eichelbrenner). If the pressure gradient is different from zero the computation becomes difficult. Flügge-Lotz and Eichelbrenner gave a solution of the problem in its older formulation $u(x,y)$ and $T(x,y)$ by using differences. I. Ginzel, E. Gruschwitz, and A. Johnson extended the von Kármán momentum theory of the incompressible layer in different ways in order to compute the flow in the compressible layer.

Author discusses first the possibility of solving the equations for $\tau(x,u)$ and $T(x,u)$ by differences, a method which the reviewer has been studying for some time. Author discards this possibility because he thinks that this procedure is laborious and inaccurate, and he suggests a new and interesting approximate procedure. He does not compute $T(x,u)$ out of the differential equations, but he takes for $T(x,u)$ at a given point x (measured from that point, where the boundary layer starts) the plate solution for the desired outer-edge velocity. This solution gives locally the desired wall and outer-edge temperatures or the desired heat transfer at the wall and the desired outer-edge temperature. This temperature distribution and an estimate of $\partial T(x,u)/\partial x$ based on this strip use of the plate solution is put in the energy equation. The energy equation, which is nonlinear in T but linear in τ^2, and its first derivative are then used for computing $\tau^2(x,u)$. Author disregards the first differential equation, which is usually considered as the main equation for τ, because, in the incompressible case, this equation is not coupled to the temperature equation and serves for computing τ. The ideas on which the new solution is based are discussed in detail. As support for his contention that the history of the layer is less important than the local conditions, the author gives one numerical example and compares its solution to results gained by other methods. I. Flügge-Lotz, USA

560. **Preston, J. H., Gregory, N., and Rawcliffe, A. G., The theoretical estimation of power requirements for slot-suction aerofoils, with numerical results for two thick Griffith type sections,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2577, 27 pp., June 1948, published 1953.

The waste of kinetic energy in wake and slipstream can be avoided if the boundary layer at the trailing edge has its total head restored by a pump. The power requirements of the suction pump are calculated, neglecting slot and duct losses. The drag of two Griffith airfoils (30 and 31.5% thick) with suction is compared with the drag of 20% thick airfoils without suction. A considerable decrease in drag of the suction airfoils is found when the suction slots are located at the boundary-layer transition. Further gains can be expected by using highly efficient gas-turbine compressors as pumps. 25 graphs are valuable to designers who use Griffith-type airfoils. G. R. Graetzer, USA

561. **Dryden, H. L., Review of published data on the effect of roughness on transition from laminar to turbulent flow,** *J. aero. Sci.* **20,** 7, 477–482, July 1953.

Author re-analyzes published data on the effect of roughness on transition from laminar to turbulent flow. For a flat plate (no pressure gradient), $x_t = x_t(x_0; x_k; k; V; \nu)$, where ν is viscosity, V velocity of the main flow, k height of roughness element, x_k, x_t, x_0 are coordinates of position of roughness element and transition points on plate with and without roughness element (the latter is a measure of the turbulence level of the main flow). It follows from dimensional considerations that there are four independent nondimensional parameters. Author shows that for $x_t >$ and not too close to x_k, Re_t/Re_0 can be reasonably well represented as a function of one single parameter (instead of three), viz., of $k/\delta_k^*(\delta_k^*$ is displacement thickness $= 1.72\nu^{1/2}x_k^{1/2}V^{-1/2}$; $Re_t = Vx_t/\nu$; $Re_0 = Vx_0/\nu$). Paper includes a discussion on roughness effects on transition on airfoils.

H. Wijker, Holland

562. **Ross, D., A new analysis of Nikuradse's experiments on turbulent flow in smooth pipes,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 651–667, 1953.

Author examines Nikuradse's experimental data on pipe flow and rederives equations of velocity profile and wall friction through more discriminating choice from the whole set of original data, without the "shift" already discovered before. New analysis includes wall-friction formula and shape parameter, both in terms of momentum-thickness Reynolds number.

L. S. Dzung, Switzerland

563. **Zísina-Molozhen, L. M., Turbulent boundary layer in the presence of a longitudinal drop in pressure** (in Russian), *Zh. tekh. Fiz.* **22,** 11, 1756–1772, Nov. 1952.

564. **Mikheev, M. A., Heat emission by a turbulent flow of fluid in pipes** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1448–1454, Oct. 1952.

Aerodynamics of Flight; Wind Forces

(See also Revs. 550, 573, 587)

565. **Eggleston, J. M., and Mathews, C. W., Application of several methods for determining transfer functions and frequency response of aircraft from flight data,** *NACA TN* 2997, 74 pp., Sept. 1953.

Paper discusses practical aspects of three methods of studying transient response from flight test data; these methods are (1) sinusoidal response methods, (2) Fourier integral methods, (3) curve-fitting methods. Emphasis is placed on various computational techniques. There is a good discussion of effects of input shape and record length, and of other types of errors. Paper is quite lucid and will therefore serve as a valuable introduction to practical aspects of this problem. H. N. Abramson, USA

566. **Amer, K. B., and Tapscott, R. J., Studies of the lateral-directional flying qualities of a tandem helicopter in forward flight,** *NACA TN* 2984, 42 pp., Aug. 1953.

An investigation of the lateral-directional flying qualities of a

tandem-rotor helicopter in forward flight was undertaken to determine desirable goals for helicopter lateral-directional flying qualities and possible methods of achieving these goals in the tandem-rotor helicopter. On the basis of comparisons between flight measurements for various configurations and corresponding pilots' opinions, it is concluded that some important considerations are: The presence of pedal-fixed directional stability; no reversal in rolling velocity during a turn following a lateral step displacement of the control stick with pedals fixed; and reasonably well-damped lateral-directional oscillations. These conclusions are also expressed in the form of desirable flying-qualities goals.

Comparison between directional stability as measured in flight and rotor-off model tests in a wind tunnel shows qualitative agreement and, hence, indicates such wind-tunnel tests, despite the absence of the rotors, to be one effective method of studying means of improving the directional stability of the tandem helicopter.

Flight-test measurements of turns and oscillations, in conjunction with analytical studies, suggest possible practical methods of achieving the goals of satisfactory turn and oscillatory characteristics in the tandem helicopter. From authors' summary

567. Morris, D. E., and Morrall, J. C., The effect of slipstream on the longitudinal stability of multi-engined aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2701, 9 pp., Nov. 1948, published 1953.

Flight measurements of longitudinal stability power-off and power-on, made on numerous aircraft, have been analyzed and a generalized curve for estimating the contribution of slipstream to longitudinal stability, applicable to both flaps-up and flaps-down cases, has been derived. Using this curve the change in stability due to slipstream at a given value of C_L can be estimated with a probable error of less than $\pm$ 0.02 in the position of the neutral point. From authors' summary

568. Beane, Beverly, Examples of drag reduction for delta wings, *Douglas Aircr. Co. Rep.* SM-14447, 42 pp., Jan. 1953.

Author uses method of E. W. Graham [AMR **6,** Rev. 1974] to define a few loadings orthogonal to a flat plate and evaluates reduction in drag by combining the correct proportion of orthogonal and original flat-plate loading. Considered are several examples having discontinuous twist, camber, or thickness-ratio distributions, for reducing lift drag per constant total lift and thickness drag per constant total volume or total frontal area. Lift-drag reduction of about five per cent is obtained with decreased tip loading for subsonic leading edges, less for supersonic leading edges. Thickness-drag reduction is obtained with thicker sections or greater volume at the inboard portions of the wing: about 1 per cent for thickness, 15 per cent for volume. Method is applicable for many other configurations in the search for minimum drag. J. De Young, USA

569. Rodriguez, A. M., Lagerstrom, P. A., and Graham, E. W., Theorems concerning the drag reduction of wings of fixed planform, *Douglas Aircr. Co. Rep.* SM-14445, 24 pp., Mar. 1953.

Problem is to calculate camber, twist, and mean angle of attack that makes a wing of fixed planform and given lift in supersonic flow have minimum drag. The method of E. W. Graham [AMR **6,** Rev. 1974] is studied and extended. Several general theorems concerning orthogonal loadings are proved, and the Jones criterion for minimum drag is shown to follow. Significance of neglecting leading edge suction in the derivation of the theorems is discussed. Authors state that further research is needed to shorten the procedure for obtaining minimum drag and that a method for estimating the difference between the drag of a given loading and the minimum drag would be useful.

N. Tetervin, USA

570. Cumming R. W., Gregory, N., and Walker, W. S., An investigation of the use of an auxiliary slot to re-establish laminar flow on low-drag aerofoils, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2742, 14 pp., Mar., 1950, published 1953.

The use of an auxiliary slot on a laminar-flow airfoil has been investigated to check whether laminar flow can be re-established by suction at the rear of the region of deposited dirt, flies, etc.

Results indicate that, in the absence of unfavorable pressure gradients, it is possible to re-establish a laminar boundary layer by removing a little more than the whole turbulent layer reaching the slot, and preliminary estimates suggest that with efficient ducting it should be possible to achieve a reduction in over-all effective drag coefficient by this means.

From authors' summary

571. Batson, A. S., Burge, C. H., and Greening, J. R., Part I; Batson, A. S., Burge, C. H., and Skelton, W. C., Part II, III, The effect of curvature of surface and thickness of trailing edge on aileron hinge moments, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2506, 48 pp., Oct. 1942, published 1953.

Paper is a summary of experiments performed in 1942 to further investigate the effects of aileron contour modifications on hinge moment characteristics. In this series of experiments the effect on hinge moment of changing the position of the maximum bulge along a control chord, together with the effect of varying trailing-edge thickness, was found. Low-speed wind-tunnel data indicated that the tendency to overbalance over a limited range of upward aileron deflection was much aggravated by convexing either or both surfaces, but was reduced by thickening the trailing edge. L. Segel, USA

572. Gabeaud, L., A new attempt to evaluate the aerodynamic drag of projectiles (in French), *Mém. Artill. fr.* **26,** 1, 169–252, 1952.

Author revises and extends methods he previously proposed [title source **15,** 4, 1936] for estimating total drag of a projectile including the contributions of ogive nose, base pressure, skin friction, boat-tail, belts, and flats. Below its critical Mach number, pressure distribution over the nose of a body of revolution is calculated using a compressibility correction based on the isentropic Bernoulli equation and an "equivalent incompressible flow." In the latter, the effective free-stream velocity and boundary conditions vary from one point of the actual flow to another, but the approximate calculation neglects these variations. The incompressible pressures are found by a modification of von Kármán's line-source technique. Above critical speed, the subsonic regime is calculated from an assumed relationship between pressure, flight Mach number, and local inclination, which is faired into results of the compressibility correction at $M_{crit.}$ Pressures in the supersonic regime are predicted on the hypothesis that, beyond the sonic line, flow conditions vary with local inclination just as they would immediately after an impulsive start from rest into a fluid whose artificial ambient properties are defined by fitting at the sonic line. Although originally devised for blunt-nosed bodies, these methods are adapted to pointed noses by using a slightly rounded nose for subsonic flight or detached bow shock and conical-shock theory for attached bow shock.

Momentum considerations are employed to compute the base pressure from a wake of ring vortexes formed by rolling-up of appropriate lengths of the shed boundary layer. Because of a

change in the assumed velocity of the vortex cores when Mach number around the base passes through unity, the base-pressure law exhibits a discontinuity in the transonic range. This is removed by speculating that between flight Mach numbers of 0.92 and 1.10 the vortexes are shed into a flow field partly subsonic and partly supersonic in nature. Various experimental data are presented to verify the base-pressure law, and explanations are offered for apparent discrepancies. The effect of decreasing Reynolds number is accounted for by constructing individual wake vortexes out of increasing lengths of boundary layer, an empirical rule being deduced from data of Hankins [Proc. Seventh Cong. Appl. Mech., Paris, 1946].

Pressures on a boat-tail in subsonic flow are calculated by the afore-mentioned compressibility correction from those at points of equal inclination on a "half-body" in incompressible fluid. For the supersonic regime, pressure defect is again regarded as a function of local inclination only; the same relationship is assumed between expansion and compression flows of revolution that exists between corresponding flows over two-dimensional inclined bodies. Base pressure behind a boat-tail is reduced below that on a sharply cut-off base in a manner related empirically to the average pressure on the tail. Frictional resistance, which is stated to be negligibly small for common artillery projectiles, is obtained from measurements on a flat plate of equivalent area and Reynolds number. The drags of belts and nose flats are equated to the total and frontal drags, respectively, of cylindrical bullets having the same cross-sectional area.

Predicted total drags are compared with measured values from French artillery tables for typical subsonic and supersonic projectiles. The supersonic predictions are reasonably accurate, except for small overestimation of base drag near $M = 1.4$. The subsonic predictions are consistently high and force the author to re-evaluate his base-pressure formulas.

Reviewer believes the methods of this paper are best described as semiempirical. In the author's words, each one is "an approximate solution, easily applied." As such, they may be very useful to the ballistician if fully verified experimentally. Although most theoretical work is sound, author occasionally displays lack of understanding of the fundamentals of fluid mechanics. Thus he compares his compressibility correction at Mach number unity with the von Kármán-Tsien formula, which is intended to apply only for two-dimensional subcritical flow. Elsewhere, he misinterprets an estimate due to Joukowsky and Pérès of the strength of a vortex formed from length L of a shed boundary layer. His readiness to discard experimental data in conflict with this theory is sometimes disconcerting.

H. Ashley, USA

Aeroelasticity (Flutter, Divergence, etc.)

573. de Vries, G., Simplified method for the rapid estimation of the flutter speed (in French), *Rech. aéro.* no. 33, 29–40, 1953.

The method uses two-dimensional aerodynamic derivatives found for a given reference section, these derivatives being expressed as simple algebraic functions of the frequency. The generalized inertias and stiffnesses are found from tests on the ground.

Simple expressions for the flutter speed are given for wing-flexure torsion taking (1) quasi-static values of the aerodynamic forces, and (2) expanding the derivatives in terms of the frequency. The latter method gives good agreement with exact calculations.

Considering wing-aileron flutter, it is shown that any approximate formula may give a completely false answer for the flutter speed. Such formulas are best used to assess the relative damping.

The usefulness of this paper is vitiated by its mathematical presentation which makes it impossible to be understood without consulting the references given, hardly any of which are widely known. Equations II_2 are incorrectly stated on page 36.

A. W. Babister, Scotland

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 553, 556)

574. Morelli, D. A., and Bowerman, R. D., Pressure distributions on the blade of axial-flow propeller pump, *Trans. ASME* **75,** 6, 1007–1012, Aug. 1953.

In the design of screw propellers, the demand for uniform energy input at all radii is satisfied by a blade circulation constant over the radius. With the authors' additional assumption of linear increase of circulation strength in axial direction, an approximative formula is given for the disturbance velocities in the blade space dependent on radius and distance from the blade's leading edge; they effect a curvature of the free streamlines which require a curvature of the blade profile computed according to airfoil theory.

Using this formula a propeller pump has been designed; its pressure distribution has been investigated by means of a rotating manometer under various working conditions. The measurements approximately agree with potential-theoretical pressure distributions. In design condition, the energy supply proves to be really uniform over the radius; hereby, the practical use of this design method is shown.

H. Krüger, Germany

575. Olderin, E., Investigation of turbine blade cascades (in German), *Forsch. Geb. Ing.-Wes.* **19,** 2, 44–48, Aug. 1953.

Author compares three types of turbine blade cascades in a two-dimensional wind tunnel. The blade forms are described as: (a) Older profile, using minimum number of circular arcs and straight lines; (b) more refined form, straight lines replaced by arcs of large radius; (c) newer form, radius of curvature varying along the profile. On each type the stagnation pressure and static pressure at entrance and at exit were measured with entrance-flow Mach number up to 0.7. The loss of stagnation pressure was found to be highest for (b) and lowest for (c). Some schlieren photographs are shown. No quantitative geometrical data of the three profile forms are given.

L. S. Dzung, Switzerland

576. Smith, L. H., Jr., Traugott, S. C., and Wislicenus, G. F., A practical solution of a three-dimensional flow problem of axial-flow turbomachinery, *Trans. ASME* **75,** 5, 789–799, July 1953.

Paper presents methods of determining the meridional flow pattern through turbomachines when there are strong departures from free vortex flow, arising from endeavor to design compressors and turbines for maximum head and flow, subject to Mach number limitations.

Frictionless flow, an infinite number of vanes, and axial symmetry are assumed, though authors themselves admit "that there is no known physical reason why this assumption should be considered as sufficiently accurate to describe the flow through actual vane systems of finite vane spacing."

Methods of computation are described and results given of two worked examples, reference being made to M.S. theses by two of the authors for full details.

Paper is an interesting contribution to the analysis of flow in turbomachinery, but experimental confirmation of its value has yet to be obtained. A. Burn, Australia

577. Johnsen, I. A., and Ginsburg, A., Some NACA research on centrifugal compressors, *Trans. ASME* **75,** 5, 805–814, July 1953.

Paper represents effort to replace some of the "art" of centrifugal compressor design with a better understanding of the flow processes taking place. It summarizes some of the results obtained in the NACA theoretical and experimental research program on centrifugal compressors. First section deals with impeller research, discussing the inducer function and the impeller function. These were investigated and analyzed separately as much as possible, and the effect of configuration on performance noted. Second section deals with vaneless diffuser research. Purpose of paper is to establish general trends of good design practice rather than to establish specific rules. A. H. Church, USA

578. Sears, W. R., A theory of "rotating stall" in axial-flow compressors, Grad. School of Aeronautical Engng., Cornell Univ., Ithaca, N. Y., 26 pp., 5 figs., Jan. 1953.

Possible theoretical explanation is sought of "rotating-stall" phenomenon in axial-flow compressors. Earlier work of author [AMR **6,** Rev. 3181] postulated time lag in the development of lift for the stalled blades and led to determination of eigen-solutions representing alternately stalled and unstalled areas that can rotate at a speed different from the rotor speed. Present paper arrives at similar results but is less restrictive in its assumptions and employs both airfoil-type and channel-type relations for the blade characteristics. Author suggests that further exploration of unsteady viscous effects for dynamic stall conditions is needed. I. E. Garrick, USA

579. Kestin, J., and Owczarek, J. A., The expression for work in a Root's blower, *Instn. mech. Engrs. Proc.* (*B*) **1B,** 3, 91–94, 1952.

Authors derive a practical expression for work, which takes into account the inherent irreversibility of the compression process and the finite delivery volume.

Reviewer believes that authors' very simple thermodynamical considerations result in an adequate analysis and computation scheme, which represents with good accuracy the actual process. It may, therefore, be expected that authors' work formulas will be of great practical interest for the designer of such blowers. P. Schwaar, Switzerland

580. Kearton, W. J., Effects of inertia on flow of steam through nozzles and blading of axial-flow turbines, *Instn. mech. Engrs. Proc.* (*A*) **166,** 4, 429–435, 1952.

Title refers to "vortex-flow" theory of designing turbine blades, first widely used for gas turbines. Theory assumes radial equilibrium in spaces between stationary nozzles and moving blades, i.e., pressure gradient is established here just sufficient to maintain circular component motion of fluid in plane perpendicular to axis; blade angles are intended to assure that fluid leaving nozzle will merge smoothly with flow in this space, and that fluid leaving space will enter moving blade passages smoothly. Increase of pressure in outward direction results in increase of reaction with radius, i.e., of fraction of total pressure drop which occurs in moving blades. Author develops trial-and-error method of calculating numerical values—including variation of pressure, degree of reaction, and blade angle with radius—when steam is working medium, and illustrates method by numerical example. Theoretical method of calculating variation of pressure when nozzle blade angle is kept constant is also developed. Author's results emphasize that vortex-flow theory as commonly applied to compressed fluids can be only an approximation at best, since it is not consistent with continuity of flow. C. W. Smith, USA

581. Krause, H. G. L., General theory of multistage rockets (in German), *Weltraumfahrt* no. 2, 52–59, Apr. 1953.

The ratio of the working load to total weight becomes a maximum if the ratio of " total weights of one stage to the following stage is the same for all stages. The best number of stages depends on this stage ratio and on the ratios, working load to total weight, and fuel weight to total weight. A. Betz, Germany

582. Levin, A. M., Position of the breakaway point in plane diffusers (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **87,** 5, 705–707, Dec. 1952.

583. Tyabin, N. V., Flow of a viscous-plastic fluid of the dispersive system in the diffuser and the immersion of a wedge in a dispersive system (in Russian). *Dokladi Akad. Nauk SSSR* (*N.S.*) **84,** 5, 943–946, June 1952.

Flow and Flight Test Techniques

(See also Revs. 524, 575)

584. von Doenhoff, A. E., Braslow, A. L., and Schwartzberg, M. A., Studies of the use of Freon-12 as a wind-tunnel testing medium, *NACA TN* 3000, 57 pp., Aug. 1953.

Advantages of use of Freon-12 for wind-tunnel testing are now well known (e.g., see *NACA TN* 1024, 1946). Compared with air, for given size, temperature, and pressure, the required Mach number can be obtained at twice the Reynolds number with half the power. Principal difficulty is that γ is only 1.13 for Freon, compared with 1.4 for air. In this paper, method of correcting for difference of γ is developed, based on calculated area ratios for a stream tube. Ratio A_c/A, where A_c is area at local Mach number of 1, is used as similarity parameter instead of Mach number. Author shows that this "streamline similarity" is nearly consistent with transonic similarity theory. Conversion factors are derived for correcting measured values of pressure, force, and moment coefficients in Freon to corresponding value in air. Derivation of these factors is partly empirical, but good agreement is obtained with large number of experimental results, at Mach numbers up to 1.2. Reviewer suggests that corrections of this kind would probably be less satisfactory at higher Mach numbers.

Modifications made to Langley low-turbulence pressure tunnel for use of Freon-12 are described. W. A. Mair, England

585. Grey, J., and Nagamatsu, H. T., The effects of air condensation on properties of flow and their measurement in a hypersonic wind tunnel, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 529–546, 1953.

Paper describes experiments made in 5-in. hypersonic tunnel at GALCIT to investigate validity of Buhler's "saturated expansion" theory [Hypersonic Wind Tunnel Memo. no. 1, GALCIT, 1950]. This theory treats air as diatomic vapor with single saturation curve (not as mixture of two or more gases) and assumes expansion along saturation curve.

Pitot-static pressure surveys along tunnel center line showed that change from supersaturated to saturated state occurred gradually, not as condensation shock. For Mach numbers higher than those in condensation region, expansion followed saturation

curve as in Buhler's theory. Experiments on oblique shock waves in saturated flow gave good agreement with calculation based on Buhler's theory. Major difficulty in further application of condensed-air hypersonic wind tunnel is lack of a significant flow parameter comparable to Mach number in single-phase gas flow.
W. A. Mair, England

586. **Liu, T.-S., The running time for supersonic blowdown wind tunnels,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 547–566, 1953.

Author has theoretically determined the duration parameter in the case of eight different types of intermittent tunnels. He has compared his results with, mainly, American tunnels. The comparison seems to show that the theory predicts conservative estimates of the running time. It is rather interesting to note that the variation of stagnation temperature has no significant effect on the duration parameter after about 10 sec. The predicted running time is higher than actual when the running time increases beyond 40 sec, except in one isolated case (Princeton 4″ × 8″), where the actual running times seems to be higher. Reviewer believes that the results will be helpful in the design of intermittent supersonic and hypersonic tunnels.
Y. V. G. Acharya, Holland

587. **Trouncer, J., and Moss, G. F., Low-speed wind-tunnel tests on two 45° sweptback wings of aspect ratios 4.5 and 3.0 (models A and B),** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2710, 43 pp., June 1947, published 1953.

588. **Dowdell, R. B., and Liddle, A. H., Jr., Measurement of pulsating flow with propeller and turbine-type meters,** *Trans. ASME* **75,** 5, 961–966, July 1953.

It was found that, in incompressible flow, several instruments indicated total flow accurately to within 2%, but authors point out that, quite possibly, resonance effects may cause large errors when the conditions of nonsteady flow are different from those employed in their experiments. In similar tests with compressible flow, considerable errors were noted under some conditions. Flow pulsations were produced in all experiments with the aid of butterfly valves, and the experimental setups are described in detail.
G. Rudinger, USA

589. **Ilyukhin, N. V., and Naurits, L. N., Experimental study of a flow-type measuring device for temperature in a high-velocity gas stream** (in Russian), *Zh. tekh. Fiz.* **22,** 12, 2014–2025, Dec. 1952.

590. **Levon, K. C., Pressure error measurement using the formation method,** *Aero. Res. Counc. curr. Pap.* no. 126, 10 pp., 5 figs., 1953.

Measurements of "pressure error" at altitude have been made by flying several aircraft in formation with a reference aircraft whose air speed system had previously been calibrated by radar. Tests show present altimeters can lead to errors of up to ± three knots in pressure error.
R. A. Gross, USA

591. **Picard, C., Stereoscopic analysis of three-dimensional supersonic flow** (in French), *Rech. aéro.* no. 32, 15–19, 1953.

It is shown that a detailed study of stereoscopic photographs obtained by the schlieren method permits the analysis of different waves produced by a fuselage or wing in a supersonic flow regime.

The stereoscopic exploration of the shock or expansion wave field demonstrates the validity of the calculation of plane waves or waves of revolution by a modified method of first approximation; furthermore, the stereoscopic analysis allows a rough approach to the problem of wing-fuselage interaction in supersonic flow.
From author's summary by C. E. Carver, Jr., USA

592. **Holder, D. W., and North, R. J., The Toepler schlieren apparatus,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2780, 13 pp., 1953.

The governing equations of any schlieren system are given and the effects of image illumination and working range upon the sensitivity are pointed out. It is shown that the maximum sensitivity for a given range is inversely proportional to the range and is independent of any property of the optical system or the light source.

The effects of the sensitivity of the eye or the photographic emulsion are also mentioned. The equations are applied to three specific schlieren systems and are confirmed by photometric experiments with these systems. Working rules are suggested to determine dimensions of the components of a schlieren system, including its possible use for shadowgraphs.
R. G. Folsom, USA

593. **Peebles, F. N., Garber, H. J., and Jury, S. H., Preliminary studies of flow phenomena utilizing a doubly refractive liquid,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 441–454, 1953.

Previous efforts to utilize a doubly refracting liquid in the study of fluid flow problems are reviewed briefly. The preparation of a relatively new solution using a commonly available organic dye, Milling Yellow, is described. Unlike solutions used formerly, this preparation is stable indefinitely in contact with common materials found in laboratory apparatus.

Several examples are given of double-refraction stress patterns resulting from two-dimensional viscous flow. No quantitative analysis of these is attempted.
F. D. Bennett, USA

594. **Ershov, V. N., Methods of gas analysis based on use of optic-acoustic phenomena** (in Russian), *Zh. tekh. Fiz.* **22,** 6, 1022–1028, June 1952.

595. **Mikhaĭlova, N. A., Using high-speed motion-picture photography for examining the muddiness of the bottom part of a current** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1501–1506, Oct. 1952.

Thermodynamics

(See also Revs. 419, 552, 579, 580, 582, 585, 670)

596. **Stueckelberg, E. C. G., and Wanders, G., Thermodynamics in general relativity** (in French), *Helv. phys. Acta* **26,** 3/4, 307–316, 1953.

A covariant formulation is given of the differential equations governing a class of irreversible thermodynamic processes. The equations are: (1) The four equations expressing conservation of linear momentum and energy; (2) the C equations expressing conservation of the number of particles of each of the C independent substances; (3) the equation expressing the increase of entropy. The class is defined by the assumptions: (1) There exists an invariant entropy, an extensive quantity, which increases with time for each observer; (2) the $C + 5$ equations just mentioned are linearly dependent, and thus $C + 4$ variables define the state of the system; and (3) the $C + 4$ state variables can be so chosen that each of the $C + 5$ four-currents (energy, linear

momentum, entropy, matter) only depends linearly on the covariant derivatives of the state variables. Choosing the velocity components, the temperature, and the chemical potentials as state variables, and assuming that this choice satisfies assumption (3) above, the most general expressions consistent with the aforementioned assumptions are then obtained for the $C + 5$ four-currents and for the irreversibility. G. Salzman, USA

597. Rozenfel'd, L. M., Work processes of thermodynamic cycles in water-ammonium compressor refrigerators (in Russian), *Zh. tekh. Fiz.* **22**, 7, 1139–1145, July 1952.

598. Rozenfel'd, L. M., Work processes of water-ammonium thermodynamic cycles in thermal engines and their analysis presented in entropic diagrams (in Russian), *Zh. tekh. Fiz.* **22**, 7, 1124–1138, July 1952.

599. Samoĭlov, B. N., Measuring the heat capacity of metals at ultra-low temperatures (cadmium from 0.3 to 0.9 K) (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86**, 2, 281–284, Sept. 1952.

600. Hardy, J. K., Evaporation of drops of liquid, *Aero. Res. Counc. Lond. Rep. Mem.* 2805, 9 pp., Mar. 1947, published 1953.

A method is described for calculating the rate of vaporization and of the temperature for a droplet evaporating in a still atmosphere. The analysis is carried out with special reference to the problem of aircraft icing. The analytical treatment involves the implicit assumption that the rate of evaporation is small. In Eqs. (1) and (3) a negative sign has been deleted. The work described in this paper was performed in 1947 and, therefore, the paper does not contain any references to recent important contributions to the problem of icing. S. S. Penner, USA

601. Rubinshteĭn, L. I., Dynamics of evaporation of fluid mixtures governed by Raoult's law (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **87**, 3, 357–360, Nov. 1952.

602. Gukhman, A. A., G. N. Kruzhilin's formula on the interdependence of steam moisture and load (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, p. 280, Feb. 1952.

603. Stĭrikovich, M. A., Problem involved in the theory on the escape of moisture with steam (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 281–285, Feb. 1952.

604. Bogdanov, F. F., and Miropol'skiĭ, Z. L., Temperature regime of the metal of a horizontal, steam-generating tube for an organic heat carrier with a high boiling point (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 1026–1030, July 1952.

605. de Boer, J. H., The dynamical character of adsorption, New York, London, Oxford Univ. Press, 1953, 239 pp. $6.

Adsorption is the phenomenon of molecules striking a surface, remaining there for a certain length of time and then evaporating, as contrasted to absorption where molecules remain permanently attached. This book is an attempt to give a physical picture of the process using the concepts of the kinetic theory of gases. As the author says in his preface: "It is of great importance to bring home to students the relative sizes of a molecule and a centimeter. The various pictures have often been illustrated, therefore, with an imaginary 'gas of super bees.' "

Many technical applications of adsorption are of interest to engineers, to chemical engineers without question, but also to metallurgical, mechanical, and even aeronautical. A few examples of adsorption processes are removal of impurities from gases, bleaching, refining of metals, separation of gas mixtures, cathodes of vacuum tubes, heat transfer from gases to solids, boundary conditions in aerodynamics, etc. With its emphasis on the physical picture and use of a large number of numerical values, as well as the analogy to a field of "super bees," the first half of the book is an excellent introduction to the subject for any engineer with some knowledge of thermodynamics and kinetic theory. The second half is more difficult, since it is directed to research workers in the field. However, the references to current literature and the author's lucid style will enable those readers who are interested to obtain a current picture of progress in the field of adsorption. The author's own contributions make him a dependable and authoritative guide.

There are 10 chapters comprising 143 sections, a complete listing of which is out of the question, but the chapters are as follows: Chap. 1 is an introduction giving the fundamental equation $\sigma = n\tau$ where n = number of molecules striking a unit area of surface per unit time and τ is the average time a molecule remains attached. Chap. 2 is devoted to a study of the number n, and chap. 3 to the time τ. Chaps. 4 and 5 are entitled the quantity σ, and the former considers the dynamic equilibrium in adsorption and condensation phenomena, while the latter compares unimolecular and multimolecular adsorption. Langmuir's adsorption isotherm is introduced and the improvement due to Brunauer, Emmett, and Teller for multimolecular adsorption is derived. Chap. 6 is on ideal two-dimensional gases, while chap. 7 is a study of nonideal two-dimensional gases. A two-dimensional van der Waals equation is used and a study made of two-dimensional condensation. Chap. 8 continues with a study of condensation using the adsorption isotherm. Chap. 9 is on multimolecular adsorption and condensation, and chap. 10 concludes with the effect of capillaries, which is essentially the effect of surface roughness.

The author has succeeded well in attaining his goal of presenting a difficult subject clearly and succinctly. His presentation is a delight to read, and the Oxford Press has maintained its usual high standard of printing. No misprints or errors were detected. R. E. Street, USA

606. Pines, B. Ya., Adsorption, surface tension, and energy of mixing binary metallic alloys (in Russian), *Zh. tekh. Fiz.* 22, 12, 1908–1919, Dec. 1952.

607. von Kármán, T., Aerothermodynamics and combustion theory, *Aerotecnica* **33**, 1, 80–86, Feb. 1953.

As an introduction, the question is asked if the theory of phenomena encompassing simultaneous fluid mechanics, thermodynamics, and physical chemistry might be called "Aerothermochemistry" or even "Aerochemical thermodynamics." This is followed with an analysis of these factors, primarily aimed at application by the aeronautical engineer.

The equations of conservation of mass, momentum, and energy are established. The heat addition is introduced as a chemical reaction rate depending upon a chemical parameter, a specific rate constant, the activation energy, the order of the reaction, and physical properties of the substance concerned. Resulting expressions, with certain assumptions and simplifications, are applied to the case of detonation and deflagration. Whereas some cases can be handled adequately, limitations due to inadequate knowledge of the exact processes of initiation and maintenance of combustion make others contradict the experimental results.

It is suggested that many otherwise difficult flow problems in-

volving combustion might be treated by assuming that the flame front is a discontinuity; a similar treatment to that successfully applied to the shock wave. As an example, the vorticity behind a flame front is analyzed.

Suggestions are made for application of the flow discontinuity approach to problems such as stabilization limits, quenching, ignition, flame-front oscillations, and turbulence.

L. M. Tichvinsky, USA

608. **Crocco, L., Supercritical gaseous discharge with high frequency oscillations,** *Aerotecnica* **33,** 1, 46–53, Feb. 1953.

When the stability of gas flow systems, with or without combustion, is studied, it is necessary to determine the behavior of the nozzle under oscillatory conditions. This problem (interesting for its applications to combustion in rockets or in combustors for jet devices) has recently been treated by H. S. Tsien for supercritical discharge. He has investigated the case in which the oscillations in the incoming flow are isothermal (therefore nonisentropic) and has computed the departures from the steady-state behavior in the range of low frequencies and the asymptotic response to very high frequencies. For actual cases, however, the intermediate range of frequencies is of interest, and also the isothermal condition is mostly not representative. The present paper extends Tsien's treatment to the nonisothermal case for low and high frequencies, as well as for all frequencies in the isentropic case. In order to gain analytical solutions, the steady main flow is assumed one-dimensional so that the sonic line is situated exactly in the throat of the nozzle, which certainly is a rather rough approximation (also remarked by both authors). In the usual manner, the problem is linearized, assuming the perturbations to be small compared with the unperturbed quantities; therefore, the harmonic form of oscillatory time dependence can be chosen. Furthermore, nozzles are studied in which the unperturbed velocity increases linearly with the length coordinate in the neighborhood of the sonic throat (this is in good agreement with many actual nozzles). The computed values are sufficient to solve problems in the complete range of practical frequencies and Mach numbers. The isentropic case with more general velocity distributions also could be solved by numerical integration of the stated pair of first-order differential equations.

M. Schaefer, Germany

609. **Surugue, J., Kling, R., and Huchet, R., Relaxation time for exchange of energy in combustion gases** (in French), *Rech. aéro.* no. 31, 25–29, Jan.-Feb. 1953.

The relaxation times pertaining to energy exchange between degrees of freedom of molecular motion, of interest in combustion research, can be determined from values of ultrasonic wave velocities observed for various frequencies with the aid of the Pierce interferometer method. The author describes an improvement of this method especially suited for gases at high temperatures; it is based on the variation in frequency of the standing waves formed in the gas column between a quartz crystal and reflector, resulting from the change in location of the reflector. Components of the electronic equipment are described and a possible experimental setup outlined. A. Fejer, USA

610. **Summerfield, M., Recent developments in convective heat transfer with special reference to high-temperature combustion chambers,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 151–171, 1953.

Author reviews briefly the classical works of Taylor, Prandtl, and von Kármán on the heat-transfer problem in turbulent flow. When heat flux is high, the variable physical properties of the fluid become important and classical theories are not sufficient. The recent development in this subject, by taking into account the variable physical properties, is also discussed.

Y. H. Kuo, USA

611. **Schultz-Grunow, F., Similarity study of flame propagation** (in German), *Z. phys. Chem.* **200,** 211–222, 1952.

Author points out that the formulation of a similarity rule for the speed of flame propagation (w_n) requires the consideration of a great number of parameters. A formula of the older type $w_n \cdot (\tau/a)^{1/2}$ = function of a single dimensionless combination of parameters (with τ reaction time, a thermometric coefficient of heat conductivity) cannot be sufficient, and a number of independent dimensionless combinations are needed. Several such combinations are mentioned and their importance is discussed. To illustrate the deductions some examples are considered; in particular, the burning of hydrogen-oxygen mixtures with nitrogen or carbon dioxide as admixed inert gas. Some results which appeared paradoxical by the older theory are explained. Attention is also given to expressions for ignition limits.

J. M. Burgers, Holland

612. **Sergel', O. S., Theory of the phases of combustion in an engine** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 289–297, Feb. 1952.

613. **Enikolopyan, N. S., and Nalbandyan, A. B., Periodic combustion in mixtures of carbon monoxide and oxygen** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 6, 1309–1312, Aug. 1952.

614. **Chukhanov, Z. F., Theory of surface combustion. I. Pipe burner** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 8, 1160–1171, Aug. 1952.

Heat and Mass Transfer

(See also Revs. 374, 520, 521, 564, 600, 610)

615. **Eckert, E. R. G., Convective heat transfer at high velocities,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 173–192, 1953.

Heat-transfer problems connected with high-speed flow are discussed with special emphasis on possible aeronautical applications. The article presents a general survey comprising the results of such calculations and experiments as are available in such a way as to provide a statement summarizing the status of the general problem of heat transfer in high-speed flows. The discussion is necessarily restricted to high-speed flow of gases, but some results are also applicable to liquids as well. The article considers laminar and turbulent boundary-layer heat transfer and the heat transfer in the wake region of bluff bodies.

R. M. Drake, Jr., USA

616. **Clark, S. H., and Kays, W. M., Laminar-flow forced convection in rectangular tubes,** *Trans. ASME* **75,** 5, 859–866, July 1953.

Heat transfer to gases in laminar flow in rectangular tubes is considered. Constant heat-input and constant wall-temperature cases are solved by a relaxation method to give the limiting values of the Nusselt number as the tube length increases or the Reynolds number decreases. Values of the limiting Nusselt number are given for rectangular tubes of all aspect ratios. Experimental data for air as the tube-side fluid are presented to confirm the theoretical values. An empirical correction for entrance effects is derived from the experimental data. C. L. Coldren, USA

617. Ivantsov, G. P., and Lyubov, B. Ya., Heating a motionless layer on spheres with a stream of hot gas (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86,** 2, 293–296, Sept. 1952.

618. Rohsenow, W. M., Heat transfer with evaporation, "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 101–149, 1953.

This is a fairly complete critical review of the literature, with most of the results discussed in terms of a consistent and relatively small set of dimensionless parameters. The emphasis is chiefly on boiling. Here six different regimes are recognized, depending on the temperature of the heating element: (1) Heat transfer through convecting liquid to free surface where evaporation takes place. (2) Bubbles form at heating surface, but condense before reaching free surface. (3) Bubbles reach free surface. (4) Formation of an unstable continuous film of vapor on the heating surface. (5) Formation of a stable vapor film. (6) As temperature of heater rises further, radiative heat transfer plays an increasing part.

Some basic theory is given for each of these regimes, and an attempt is made to correlate the experimental data in dimensionless equations. An index and better titling would have improved the usefulness of this paper as a source.

W. Hitschfeld, Canada

619. Slepyan, E. E., Study of heat transfer in the condensation of Freon-12 on smooth and ribbed horizontal tubes (in Russian), *Zh. tekh. Fiz.* **22,** 7, 1109–1123, July 1952.

620. Gilmore, G. D., and Thayer, G. B., Some design considerations for injection-molding heating chambers, *Trans. ASME* **75,** 5, 903–906, July 1953.

Authors examine factors affecting heating capacity of injection-molding heating chambers. Heater is divided into heating and cold zones. Maximum heating with minimum pressure drop can be obtained by increasing bore of heater body and length of heating zone, decreasing thickness of section, and internally heating spreader. Optimum length of heating zone and thickness of section depend also on pressure-loss considerations. Increasing plunger diameter, heating cylinder walls, and redesigning plunger so that it pushes against molten plastic will increase flow in cold zone. Factors neglected for simplification were velocity gradient and frictional heating of plastic and heating prior to entering spreader section. Analysis is applied to specific injection molding machine. F. J. Mehringer, USA

621. Blackwell, J. H., Radial-axial heat flow in regions bounded internally by circular cylinders, *Canad. J. appl. Phys.* **31,** 4, 472–479, May 1953.

Like most solutions to complex heat-conduction problems in solids, this paper rightfully belongs in the realm of mathematical physics. Two problems are attacked analytically: (1) Transient heat flow in the infinite region bounded internally by an (infinite) circular cylinder. A constant heat flux passes through a finite length of the internal boundary, the remainder of which is insulated. (2) Transient heat flow in the semi-infinite region bounded internally by a circular cylinder and by planes at right angles to the axis of the cylinder. A constant heat flux passes through the internal boundary and the planes are kept at zero temperature.

These are solved using a Laplace transformation with respect to time and infinite Fourier transformation with respect to axial variable in the first case, and finite Fourier sine transformation with respect to axial variable in the second case. The solutions appear unique. J. A. Clark, USA

622. Voskresenskiĭ, K. D., Nonlinear problem in the theory of thermal conductivity (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **87,** 4, 575–576, Dec. 1952.

623. Ioffe, A. V., and Ioffe, A. F., Simple method of measuring thermal conductivity (in Russian), *Zh. tekh. Fiz.* **22,** 12, 2005–2013, Dec. 1952.

624. Ioffe, A. F., Estimate of thermal conductance of semiconductors (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **87,** 3, 369–372, Nov. 1952.

625. Kremnev, O. A., Variable thermal conductivity of hollow bodies bounded by a spherical cylindrical surface with a given law for its heat exchange with a cooling or heating medium (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 5, 1009–1012, Aug. 1952.

626. Vol'kenshteĭn, V. S., Rapid method of determining thermic characteristics of poor heat conductors (in Russian), *Zh. tekh. Fiz.* **22,** 6, 1043–1049, June 1952.

627. Khakimov, Kh. R., Experimental data on the removal of heat from ground during freezing (in Russian), *Gidrotekh. Stroit.* no. 11, 17–20, Nov. 1952.

628. Ivantsov, G. P., and Lyubov, B. Ya., Heating of granulated substances under conditions of counterflow (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 5, 993–995, Aug. 1952.

629. Gukhman, A. A., and Ilyukhin, N. V., Effect of temperature ratio upon the intensity of heat exchange (in Russian), *Zh. tekh. Fiz.* **22,** 5, 784–793, May 1952.

630. Schwarz, W., Total radiation pyrometer for measuring of temperature on the blades of rotating gas turbine (in German), *Brennstoff-Wärme-Kraft* **5,** 6, 195–197, June 1953.

631. Bagotskaya, I. A., Diffusion in a liquid as influenced by turbulence of stirring (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 5, 1057–1060, Aug. 1952.

Acoustics

(See also Revs. 594, 660, 662)

632. Head, J. W., The effect of wall shape on the decay of sound in an enclosure, *Acustica* **3,** 3, 174–180, 1953.

It is mostly a matter of subjective appreciation if an acoustical room is described as "good." An excellent objective criterion, for instance, is the effect of wall shape on the natural frequencies and on the normal modes of the room. From this point of view, three types of projections regularly spaced on the wall are examined by author by the Feshbach theory, after being formerly examined by experiments of Brown Boveri & Co. Research Dept. An interesting result has been confirmed. From circular, triangular, and rectangular projections, the latter were found to have the best effect on the decay of sound. Moreover, paper includes some details concluded from theory. P.-P. Heusinger, Germany

633. Meyer, E., and Güth, W., Acoustic viscous boundary layer (in German), *Acustica* **3,** 3, 185–187, 1953.

Traveling sound waves in air are produced in a long tube by a loudspeaker at one end and absorbed on the other by a cone of

absorbent material. Authors investigate the viscous boundary layer produced by a small glass cylinder placed inside the tube. Velocity distribution is measured photographically by illuminating small oil drops suspended in the boundary layer. Experimental distribution agrees very well with the theoretical calculations. K. Pohlhausen, USA

Soil Mechanics, Seepage

(See also Revs. 405, 478, 627)

634. **Foster, C. R., Reduction in soil strength with increase** in density, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 228, 13 pp., July 1953.

Usual concept about soil strength is that an increase in density will result in an increase in strength. Opposite behavior can happen under certain circumstances, as is observed in the California Bearing Ratio tests. Unconfined compressive strength tests show the same tendency at high densities.

Field tests on an experimental section of road were carried on. Loads were applied by means of a 120,000-lb cart. Results similar to those reported above were encountered in the field.

Comparison between field and laboratory data showed that CBR for field conditions were considerably higher, at equal values of moisture and density, than those of laboratory.

Author believes that the decrease of strength above certain conditions of density is caused by the development of pressure in the voids of the soil. When moisture is low in order that no significant pore pressures can develop, strength increases with density. A. Balloffet, Argentina

635. **Szymański, M., Computation of foundation stability** by means of diagrams (in Polish), *Inżyn. Budown.* **9,** 11, 367–372, Nov. 1952.

Author reports four diagrams plotted by Russian scientists M. I. Gorbunov-Posadov and V. V. Cretchmer for computation of foundations. The diagrams are designed for calculation of critical unit soil pressures allowable under strip foundations. These diagrams can be used only for cohesionless soils spread in deep layers.

The paper states that the diagrams are based on the theory of cylindric sliding surfaces, but does not explain the theoretical deductive procedure of obtaining the curves of the diagrams. For all detailed information, the reader is directed to the orginal work of Gorbunov-Posadov and Cretchmer.

R. Pietkowski, Poland

636. **Malíshev, M. V., Calculating the strength of foundations and the stability of hydrotechnical structures on soft soils** (in Russian), *Gidrotekh. Stroit.* no. 1, 36–37, Jan. 1953.

637. **Sokolovskiĭ, V. V., Stability of foundations and of** slopes (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 8, 1146–1159, Aug. 1952.

638. **Gorbunov-Posadov, M. I., Calculating the stability of sand foundations by the application of both the theory of elasticity and the theory of the limiting conditions of stress of free-flowing** media (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12,** 136–164, 1952.

639. **Terzaghi, K., Mechanism of landslides** (in Portuguese), *Inst. Pesq. Tecnol. São Paulo Separ.* no. 467, 30 pp., 1953. See AMR **4,** Rev. 3417.

THE FOLLOWING PAPERS (REVS. 640–651) WERE PUBLISHED IN *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, in 3 vols. 75 SFr per set.

640. **Croney, D., and Coleman, J. D., Soil moisture suction properties and their bearing on the moisture distribution in soils,** vol. I, 13–18.

Measurements of pore-water pressure were made under no load and under load for a number of soils to determine the effectiveness of loads on increasing the pore pressure. The pore pressure under no load is called soil moisture suction. The effectiveness of suction in improving the mechanical properties of soils is discussed. G. Pickett, USA

641. **Olsson, G., Approximate solution of the progress of consolidation in a sediment,** vol. I, 38–46.

In a sediment the vertical pressure depends on the depth below ground level and the time which has elapsed since the sedimentation started. In the paper, the vertical effective grain pressure is expressed as a product of a function of depth and time, respectively.

Using the two-dimensional continuity equation for a compressible soil and Darcy's law for seepage through porous materials, a differential equation of the first order for the time function, $\xi(t)$, has been derived, the solution of which contains the incomplete gamma function.

It is also shown how to calculate the pressure distribution during the consolidation which will take place after sedimentation is completed. The time function is obtained by integration of Darcy's equation, leading to exponential functions. By means of a set of curves the effective grain pressure distribution is determined both during and after the sedimentation process.

R. K. Bernhard, USA

642. **Dos Santos, M. P. P., A new soil constant and its applications,** vol. I, 47–50.

Paper indicates that correlation can be obtained between Atterberg limits and the grain-size distribution curve by means of new soil constant defined as the average of six specified ordinates of the grain-size distribution curve divided by 100. Empirical formulas for LL, PI, and PL are obtained on the basis of 353 samples of soil. Methods for predicting the Atterberg limits of mixtures and correlation with AC and HBR classification systems are shown. Results are of a preliminary character but are stimulating.

J. A. Cheney, USA

643. **MacLean, D. J., and Clare, K. E., Investigation of some problems in soil stabilization,** vol. I, 263–267.

Studies of factors affecting soil stabilization for road foundations reveal that the stabilization of a wide range of clay soils with cement and lime should be possible in practice. If, however, the soils contain organic matter, it is necessary to add calcium salts to the cement in order to effect satisfactory stabilization. Cohesive soils may be stabilized by addition of small quantities of surface-active waterproofing agents. Such agents apparently maintain the bearing strength of the soil under wetting conditions by reduction of water-absorption rate. Stabilization of soil may also be accomplished by the addition of 1 to 10 % by weight of phenolic-formaldehyde resins. S. R. Faris, USA

644. **Matsuo, S., Honmachi, Y., and Akai, K., A field determination of permeability,** vol. I, 268–271.

The permeability of soils under field conditions is determined by digging test pools and letting water seep from these pools into the soil. Assuming various two-dimensional flow patterns, the

permeability may then be calculated from the measured rate of seepage. Boundary effects are eliminated by enlarging the pool and repeating the measurements. This kind of measurement has many advantages over laboratory determinations on small samples. Its accuracy depends, however, on the similarity between the assumed flow pattern and the pattern actually realized. H. C. Brinkman, Indonesia

645. Edelmann, T., The consolidation of a layer, whose modulus of elasticity is proportional to the depth, vol. I, 358–361.

The compressibility of natural soils frequently increases with pressure, i.e., with depth, although not necessarily in direct proportion. On simplifying assumption of direct proportionality, author solves hydrodynamical consolidation of soil layer under uniform surcharge. Solution of the partial-differential equation governing rate of settlement is obtained by Bessel and Neumann functions and illustrated by example.

Practical usefulness of solution is limited by simplifying assumption mentioned, special loading case considered, and absence of tabular or graphical presentation of results.

G. G. Meyerhof, Canada

646. Lorenz, H., The determination of the dynamical characteristics of soils, a good help in the calculation of dynamically excited foundations, vol. I, 406–408.

Dynamical soil investigations have shown that the dynamical stress-strain diagram for soil is a concave curve, showing deformation of soil due to dynamically increasing pressure to increase disproportionately. Large-scale tests have proved that existence of such characteristics, called sublinear characteristics, explain all the so far inexplicable phenomena, such as decrease of natural frequency with increasing exciting force, decrease of natural frequency with increasing static pressure, and increase of natural frequency with increasing base area with constant pressure. This characteristic presents useful means for describing dynamical soil properties.

It is possible from this characteristic to derive a tangent value, which author terms "dynamical bedding value." Dynamical bedding value does not aim to be a pure soil constant because it depends, in addition to soil properties, on the total stress as well. The paper describes three different methods for calculating dynamical bedding value, utilizing investigation by means of heavy vibrator. Numerical example illustrates the methods and gives an indication of their accuracy. S. K. Ghaswala, India

647. Antoine, J., L'Herminier, R., and Bachelier, M., Bearing capacity of large diameter piles resting on a low limestone bank (in French), vol. II, 3–6.

The purpose of this study is to determine the bearing capacity of a pile resting on a limestone bank of thickness varying between 0.30 and 1.30 m. This limestone bank is superimposed on a layer of compressible marl 1.30 m thick. The limestone bank of variable thickness was considered as a three-layer slab.

Westergaard's studies concerned two-layer systems in which the lower layer was semi-infinite. Therefore, an attempt was made to replace the two lower layers by a fictitious semi-infinite layer giving the same deflection at the interface.

First, the tensile strength of the upper part of the limestone bank was measured at the laboratory, and second, the modulus of elasticity of the limestone and that of the underlying layer of marl were measured. In this way, the minimum thickness of the limestone bank, necessary to avoid slab rupture, was determined.

From authors' summary

648. Cambefort, H., The bearing capacity of pile groups (in French), vol. II, 22–28.

649. Cambefort, H., The behavior of bored piles and penetration tests (in French), vol. II, 29–36.

650. Holtz, W. G., and Gibbs, H. J., Field tests to determine the behavior of piles in loess, vol. II, 51–56.

651. van der Veen, C., The bearing capacity of a pile, vol. II, 84–90.

Micromeritics

(See also Revs. 515, 530, 644, 663)

652. DallaValle, J. M., Orr, C., Jr., and Blocker, H. G., Settling of particles in a thermal gradient, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 741–757, 1953.

This is an account of a very preliminary investigation into the settling of aerosols in vertical columns, in which known thermal gradients (positive, zero, or negative) are maintained. The magnesium carbonate aerosol was produced by an "elutriator"; no effort was apparently made to control particle size or shape. After settling through the chambers (one brass and thermally lagged, the other glass and not specially lagged) the particles were collected on glass or aluminum disks; the mass deposited during successive intervals was determined by chemical methods. The results were quite different in the two chambers, supposedly due to the differences in the temperature distributions. Rates of settling were, however, quite different even when the temperatures in both chambers were uniform throughout. Similar disagreement was found in attempts to compare particle-size distributions determined microscopically with distributions determined from the settling data. The authors ascribe this to a wall effect which they should and could surely have removed.

One definite conclusion drawn is that the rate of settling depends not merely on the mean temperature but on the detailed temperature distribution throughout the length of the column. No attempt was made to correlate the rate of settling with the thermal gradient. W. Hitschfeld, Canada

653. Vanoni, V. A., A summary of sediment transportation mechanics, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 129–160, 1953.

Even a brief survey of the mechanics of sediment transportation, such as the present one, indicates clearly that sediment movement is intimately associated with turbulence. Observations of the erratic intermittent motions of grains on a bed are explained with any degree of satisfaction only in terms of the pattern of turbulence in the flow, and the behavior of suspended material is even more closely tied in with turbulent motion. The theories presented in this summary represent the best information that is available at this time, yet it is clear that they fall short of achieving a quantitative description of the phenomena.

In the early days of sediment transportation investigations, attempts were made to develop simple transport formulas that could be applied directly to engineering problems. This ambitious objective met with little success, and researches in recent years have been going more and more into the study of the basic phenomena involved and have clarified some of the problems. Much yet remains to be done on this important and interesting but very complicated problem. From author's summary

654. Gottschalk, L. C., Measurement of sedimentation in small reservoirs, *Trans. Amer. Soc. civ. Engrs.* **117,** 59–69, 1952.

Measurements of sediment volume provide a basis for proper

operation and design of reservoirs. Author describes in some detail the methods in current use: (1) Direct measurement of sediment thickness; and (2) volumes based on original and present topographic maps. Methods are claimed to give results within 10% of true values. W. DeLapp, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 390, 482, 538)

655. **Ogawara, M., and Yamazaki, H., Statistical method of estimating isoclines,** *Pap. Meteor. Geophys.* **3,** 2, 77–93, Aug. 1953.

Although maps of isobars, isotherms, and similar isopleths are fundamental to meteorology and climatology, the basic problem of drawing these lines from a restricted number of observations of limited accuracy has not been widely discussed. The present author rejects the so-called "objective" method of analysis due to Panofsky, because it implies that the variable being analyzed has a known functional form in terms of the coordinates. The author prefers linear interpolation between adjacent points and determines the probable range of the intersection of an isopleth and the line joining the two points from the known errors of the observations. He applies this method to the drawing of climatological and synoptic charts. The method is too elaborate for routine synoptic use, but is enlightening in regard to the uncertainties contained in any meteorological map. The author also gives a more general theoretical treatment in which the isopleth position is determined from the observed values at n points.

J. S. Sawyer, England

656. **Bunker, A. F., Diffusion, entrainment and frictional drag associated with non-saturated, buoyant air parcels rising through a turbulent air mass,** *J. Meteor.* **10,** 3, 212–218, June 1953.

Under certain conditions of instability in the lower atmosphere, the phenomenon of buoyant air bubbles rising through the unstable regions may be found.

Through additions to the air-entrainment equations of Houghton and Cramer, and by means of some assumptions, author derives differential equations expressing changes of temperature excess within and the vertical velocity of these ascending bubbles of air. Using meteorological data for several specific occasions, the derived equations predict survival of buoyant air parcels—a fact confirmed by observations.

Of interest are certain characteristics of the air bubbles: (a) Their radius is of the order of 100 m at low levels and 1500 m at altitudes of 600 m; (b) radius to thickness ratios vary between 10 and 2; (c) vertical velocity within the bubbles may exceed, by an order of magnitude, turbulence speeds in the surrounding air; (d) temperature excesses of 0.6 d. Celsius may be found; (e) a drag coefficient of 0.1 was found to yield results in agreement with observations. W. W. Berning, USA

657. **Arakawa, H., Vorticity waves in the tropical latitudes,** *Pap. Meteor. Geophys.* **3,** 4, 269–276, Mar. 1953.

Treating a steady frictionless zonal current of infinite width, author gives solution of vorticity equation for superposed autobarotropic wave perturbation contained in meridionally sloping plane. On the basis of novel result, viz., angle of slope = geographical latitude, author claims to strengthen evidence for applicability of earlier horizontal-plane wave solution (Rossby) to low rather than high latitudes. Haurwitz's solution for current of finite width is used (a) to explain kinematics of meandering and well-developed "blocks" of middle latitude westerlies, and (b) to account for quasi-horizontal eddy motion in tropical easterlies and for frequently observed equatorial westerlies.

F. A. Berson, Australia

658. **Kasahara, A., A note on the vertical structure of the pressure and temperature fields in a typhoon,** *J. meteor. Soc. Japan* **31,** 1, 22–35, Jan. 1953.

659. **Ichiye, T., A short note on energy transfer from wind to waves and currents,** *Oceanogr. Mag.* **4,** 3, 89–93, Dec. 1952.

The wind waves and drift currents are both generated as results of energy transfer from the wind and, heretofore, the process of these two phenomena has been theoretically treated independently of each other. However, the basic idea about the relation of these different phenomena seems to remain somewhat obscure. The author has been interested in such a problem and here offers some remarks. From author's summary

660. **Carhart, R. R., Reflection of sound in the ocean from temperature changes,** *J. appl. Phys.* **24,** 7, 929–934, July 1953.

This is a very readable discussion of reflection of sound by a layer in which acoustic velocity changes gradually, compared to the more familiar case when the reflecting layer has negligible thickness. Calculated numerical relations are presented by numerous graphs, referring mainly to total velocity changes of less than 0.1% and glancing angles of less than 5°. All results refer either to an abrupt velocity change or to a gradual transition of one specific form, for which a reflection formula is quoted without derivation. P. Rudnick, USA

661. **Miyake, Y., A table of the saturated vapour pressure of sea water,** *Oceanogr. Mag.* 4, 3, 95–118, Dec. 1952.

662. **Vogel, C. B., Piezoelectric well hydrophones,** *J. acoust. Soc. Amer.* **25,** 4, 711–718, July 1953.

The described piezoelectric well hydrophones, which are constructed for seismic prospecting of minerals by means of measuring the velocity of sound in the earth, have as sensing elements tourmaline or barium-titanate crystals, the use of latter being restricted to temperatures below 212 F. Since hydrophones are coupled to the earth by means of the well water, their contact is more constant than with other geophones, thus reducing the noise of the system and facilitating the resolution of shear waves. The construction of some hydrophones with varying sensitivity is given; several measured diagrams are discussed.

Margot Herbeck, Germany

663. **van Everdingen, A. F., The skin effect and its influence on the productive capacity of a well,** *J. Petr. Technol.* **5,** 6, 171–176, June 1953.

Author evaluates the relationship between pressure drop in a well per unit rate of flow and such properties as formation permeability, fluid viscosity, and an additional resistance to flow which is concentrated around the well bore. He suggests that this additional resistance to flow (which is defined as the skin effect) may be the result of drilling and completion techniques employed, or of the production procedure. Methods are given to determine from field data the skin effect and the product of average permeability times the thickness of the producing formation. [A comprehensive treatment of this same problem is given in a recent paper by W. Hurst, "Establishment of the skin effect and its impediment to fluid flow into a well," *Petr. Engr.*, Oct. 1953.]

J. Aronofsky, USA

664. Piskunov, N. S., Shifting of the contour of oil-bearing, and the decline of pressure in an oil bed during exploitation of large oil deposits (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **84,** 5, 907–908, June 1952.

Lubrication; Bearings; Wear

(See also Revs. 391, 517, 523)

665. Anderson, W. J., Macks, E. F., and Nemeth, Z. N., Comparison of operating characteristics of four experimental and two conventional 75-millimeter-bore cylindrical-roller bearings at high speeds, *NACA TN* 3001, 27 pp., Sept. 1953.

Purpose of this work is to study operating characteristics of roller bearings applicable to gas turbines. Previous reports have shown that roller separator is a major problem, and this report evaluates six different designs of nodular iron cages. Bearings assembled with these cages were operated with varying oil-flow rates and loads and the operating temperatures and limiting speeds were observed.

Best design tested had a straight outer-race bore with an outer-race guided cage and inner-race guided rollers. Maximum permissible speed for this design was 31,000 rpm as compared with 23,000 rpm for a bearing with conventional inner-race guided rollers and cage. Results indicate the necessity of providing easy egress for the lubricant as well as locating the cage on a surface where an adequate oil supply is assured.

J. B. Bidwell, USA

666. Anderson, W. J., Macks, E. F., and Nemeth, Z. N., Effect of bronze and nodular iron cage materials on cage slip and other performance characteristics of 75-millimeter-bore cylindrical-roller bearings at DN values to 2×10^6, *NACA TN* 3002, 24 pp., Sept. 1953.

Purpose of this report is to compare the relative performance of bronze and nodular iron cages in roller bearings operating under conditions encountered in gas turbines. Both materials were tested in bearings with outer-race guided rollers and cages. Bearings were operated with varying oil-flow rates and loads, and the operating temperatures, maximum permissible speeds, cage slip, and wear of the bearing elements were measured.

Principal difference in cage performance was higher wear experienced with nodular iron at high speed and light load. These conditions induce high cage slip. Limiting speed and operating temperatures are essentially alike. Data points out importance of frictional and wear properties of cage material when operating conditions induce slip. If slip is avoided, nodular iron and bronze are equally satisfactory. J. B. Bidwell, USA

667. Nemeth, Z. N., Macks, E. F., and Anderson, W. J., Investigation of 75-millimeter-bore deep-groove ball bearings under radial load at high speeds. II. Oil inlet temperature, viscosity and generalized cooling correlation, *NACA TN* 3003, 33 pp., Sept. 1953.

Paper describes continuation of experimental investigation of characteristics of the lubrication of ball bearings at high speeds. Dimensional analysis is used to correlate the results.

W. O. Richmond, Canada

668. Schultze, E., Settlements and permissible bearing pressures, Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953 (in 3 vols.), vol. I, 454–460. 75 SFr. per set.

The permissible bearing pressure under buildings and structures depends on the permissible settlement. A simple expression, suitable for actual practice, is still lacking for determining the bearing pressure when the amount of tolerable settlement of a single foundation is known. Paper derives such an equation from Simpson's formula by an approximate integration of the load area under a rigid foundation, and a formula is presented which permits calculation of the width of a foundation for a given load and a definite settlement.

From author's summary by O. Hoffman, USA

669. Kochanowsky, W., Influence of pressure on viscosity and its effects on lubrication of sliding surfaces (in German), *Kolloid Z.* **131,** 2, 74–83, May 1953.

Muskat and Evinger are supposed to have explained the Stribeck curves through hydrodynamic theory by considering a viscosity dependence on pressure obeying the exponential law $\eta = \eta_0 \exp c(p - p_0)/p_0$. For the coefficient of friction they attained curves which increase to infinity at low but finite sliding velocities. However, this behavior does not agree with that of the Stribeck curves, which show finite friction coefficients even at zero sliding velocity. Author demonstrates that at higher bearing loads or low sliding velocities, the Muskat-Evinger theory yields pressure distributions, which, not being real, are physically senseless. This is the consequence of the use of the exponential law being derived by interpolation of viscosity values measured at constant temperature. Actually, the temperature in the lubricating film is not constant but is raised by internal friction. This elevation counteracts the rise of viscosity by pressure. Therefore, viscosity in the film does not increase as rapidly as indicated by the exponential law. In order to observe the influence of temperature, author performs the calculations for the example of a plain slider with the viscosity law $\eta = \eta_0[1 + 2c(p - p_0)/p_0]^{1/2}$, which agrees with the exponential law at lower pressures but gives lower values than the latter at higher. Unreal pressures do not then appear at large loads and small velocities, and a statement of the loading capacity, friction force, and friction coefficient is obtained which is plausible throughout from the physical viewpoint.

Author does not intend to affirm that viscosity in the film actually obeys the above radical viscosity law. He intends only to show that the physically senseless result of the Muskat-Evinger theory is due to the too large rise of viscosity in the exponential law. The rise of the Stribeck curves toward low sliding velocities is based on the effects of solid friction and cannot be comprehended by hydrodynamics, which does not take solid friction into consideration. U. Rost, Germany

Biomechanics

670. Hardy, H. B., Jr., Vallou, J. W., and Wetmore, O. C., The prediction of equilibrium thermal comfort from physical data on fabrics, *Textile Res. J.* **23,** 1, 1–10, Jan. 1953.

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